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METALS & ALLOYS

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Devoted to the Advancement of Scientific Metallurgy

Form of Furnace for Heat Treatment

ROBERT M. KEENEY

Some Elementary Facts about Cast Iron

GEORGE M. ENOS

Preferred Orientation in Silver Foil Produced by Cold Rolling

CLEVELAND B. HOLLABAUGH

Methods of Testing Welds

GEORGE B. MOYNAHAN

NUMBER 13 | JULY 1930 | VOLUME 1

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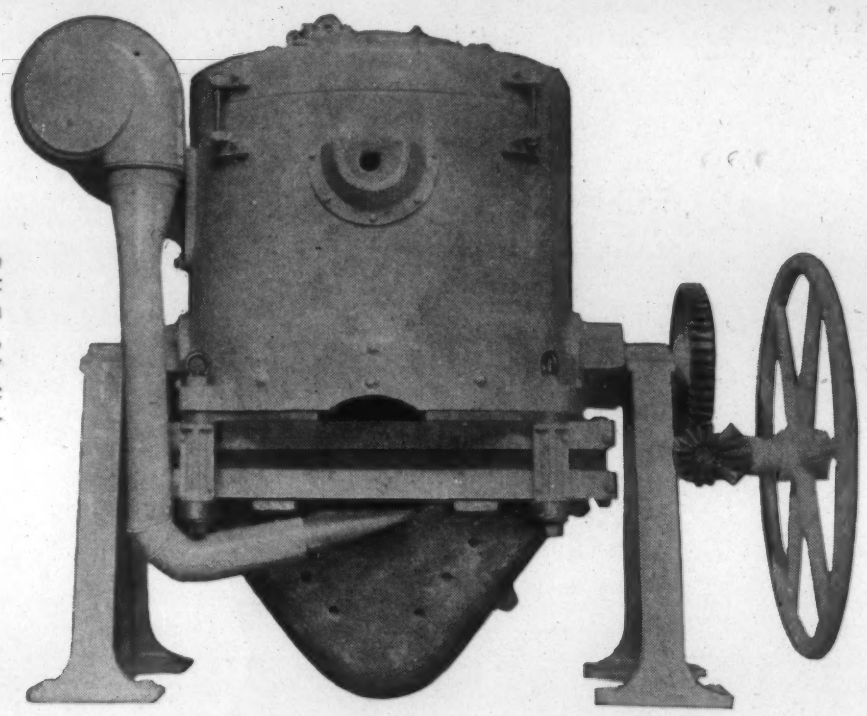

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PUBLISHER'S PAGE

Note— On this page the publishers will talk right straight to you each month. We will tell you how things are progressing with METALS & ALLOYS. *We will undoubtedly ask your advice on many points. We are publishing this paper not primarily to please ourselves but rather to serve you. And our office door is always open. You are invited to call.*

We reproduce below a page from "R-S Industrial Heat Review," an always interesting house organ published by Ryan, Scully & Company, Philadelphia, well-known industrial furnace engineers. It is a pleasure for us to use this space to give Mr. Ryan an opportunity to voice his objections to the ideas advanced by our Editorial Director in our May issue.

At the same time we are somewhat proud of the fact that METALS & ALLOYS has taken such a decided stand on keeping "Puffs" out of its columns that it has called forth this criticism from Mr. Ryan.

R-S INDUSTRIAL HEAT REVIEW *June*

ALLEGED BUNK IN FURNACE PUBLICITY

"Much bull is thrown by furnace manufacturers and proponents of one type of fuel or another, in regard to the wonderful results shown by their furnace or their fuel in heat-treatment. We could readily fill many pages of this journal with papers of this nature written by authors with an axe to grind. Often it is true that the particular furnace described or the particular application of fuel or electricity cited does represent an advance, but if a similar application of sound engineering principles were made to other furnaces and other fuels, they, too, might show improvement.

"It is far more important to discuss the principles on which all successful heat-treatment furnace design and utilization rests than to discuss individual applications. Most of the fundamentals are known, but they are too seldom appreciated. This article and the one to follow should aid in their appreciation."

This appeared in the May issue of "Metals and Alloys," and as in that magazine we reproduce the black border. It really should have a heavier one because it is quite mournful, and within the confines of that border the editor of "Metals and Alloys" has tried to bury 90 per cent of the heat-treating industry's publicity.

The editor's not preceded an article by the well-known industrial heating engineer, Mr. Robert M. Keeney, of the Connecticut Light & Power Company. Mr. Keeney's article is called "Industrial Heat for Heat Treatment" and is so logically and clearly written that it will undoubtedly have a widespread interest. Unfortunately, the editor thinks that the addition was necessary.

The editor mentions that articles are written by authors with an axe to grind. Perhaps he doesn't realize that he was grinding an axe, his axe being the truthfulness of his magazine over other magazines.

His first sentence hurts: "Much bull is thrown by furnace manufacturers. . . ." That sentence is a public condemnation of the advertising and publicity methods of the entire industry.

The editor is hitting at magazines which, from time to time, publish articles dealing with equipment that presents some recent development in the immediate field. In these articles the manufacturer of the equipment is usually mentioned. Many times only the name appears. Most of these articles are prepared by the manufacturer. The editor did not, however, need to be so vicious in his condemnation.

I have been reading trade paper articles for quite some time, and I have written quite a few, and I have yet to see an article which deserves the brick-bat which "Metals and Alloys" has seen fit to throw.

Of course the manufacturer crows about his achievement. If he builds equipment that is good and secures results heretofore impossible, he has a right to. If I built something that was a distinct innovation, for the sake of example let us say an automobile that would run forty miles on a gallon of gasoline, I would crow. Why shouldn't I tell the world that my product is good? My story wouldn't be "bull," and I do not think that the articles of other manufacturers can be called "bull."

Consider another part of the editor's note, "Often it is true that the particular application of fuel or electricity cited does represent an advance, but if a similar application of sound engineering principles were made to other fuels, they, too, might show improvement." Of course, this is so, but the main thing is the fact that so and so developed equipment that made the improvement. Other manufacturers, of course, will in time copy these improvements, or create something better; but for the time being his equipment is the best and as such deserves such commendation and publicity as the trade journals see fit to give it.

Another sentence reads: "It is far more important to discuss the principles on which all successful heat-treatment furnace design and utilization rests than to discuss individual applications." Again we disagree with the editor. It is essential that the industry know of new ways and methods of heat-treating. That is progress. The fundamentals are known, but the big thing that the industry is seeking is new ways to apply and use the established principles.

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Editorial Comment

In this department I try to comment on metallurgical and allied matters that seem to me interesting and significant. The views expressed reflect my own personal attitude. Many of our readers will have ideas of their own on these subjects and are urged to contribute them in the form of letters which will gladly be published in succeeding issues.—H. W. GILLETT, *Editorial Director.*

An Anniversary

An anniversary is a time for looking both backward and forward, backward to see what has been accomplished, and forward toward further accomplishment and the elimination of shortcomings.

In our first issue, a year ago, we made certain statements which we repeat below, with still greater assurance.

"The *engineer*, i. e., the *user* of metals, is the one who most needs unbiased presentation of the new facts of metallurgy, for he is the one who must *apply* them to practice.

"There seems to be a real need for a journal of scientific metallurgy conducted primarily in the interest of, and from the point of view of, the *user* of metals. METALS & ALLOYS is an attempt to fill the need. Its task is to collect, and to present impartially, information on the scientific advances in both ferrous and non-ferrous metallurgy *in such form that they may be more readily assimilated into engineering practice, to bridge the gap between the sometimes abstruse findings of the research laboratory and the everyday use of those findings to make better and cheaper goods for human consumption.*"

The words are those of 1929. The italics are those of 1930.

Our readers tell us that we have made progress toward our goal in the impartial presentation of new and of fundamental information on scientific metallurgy in original articles and translations, in a very complete coverage of metallurgical literature through abstracts made by metallurgists for metallurgists, in presentation of scattered facts in assimilable form as correlated abstracts which are time-savers, and the other departments come in for appreciative words as well.

It is obvious that we should continue to expand and improve these features. And we will. But we believe that, without in any way curtailing the attention given to fundamental scientific metallurgy, we should lay still greater stress on engineering applications, on the putting into practice of advances in materials, processes and methods of control. In order to deal still more fully with these aspects of metallurgy without "skimping" on fundamental science, it is obviously necessary to have more space. And the publishers tell us that we will have more text pages in order to deal more adequately with engineering metallurgy.

Moreover, we are securing the cooperation of men who have made outstanding successes in the actual application of scientific metallurgy to production problems, who, as editorial advisors, will from time to time tell us how they have solved their own problems, and will help us to secure similar articles from others. These men constitute living links between science and practice. Some were primarily scientists, and made good when they were faced with the problem of application of science to operating problems. Others were primarily operators who delved back into metallurgical science for the facts they found they needed.

With a still deeper appreciation of the importance of engineering metallurgy, with added cooperation and added space, we take up the task of making METALS & ALLOYS still more nearly approach the ideal of service to the makers and users of metals and alloys.

A New Era in Advertising

We are impressed by the growing tendency toward a new type of advertising done directly by the research departments of progressive firms without the interposition of the "journalese" or propaganda point of view that still clings to many advertising departments.

Cold, hard facts, written up from a purely impersonal point of view, as scientifically and impartially phrased as if they had to run the gauntlet of the committee on papers and publications of a technical society, are emanating from metallurgical research departments these days, sometimes in the form of printed bulletins appearing at stated intervals, or as mimeographed ones, appearing whenever something is ready for distribution. There are shades of difference among them, but most of them give very useful scientific facts.

Among "organs" of this sort are the "Research Group News" of the Steel Founders' Research Group, the "Vancoram Review," various publications of the International Nickel Company, the Nickel Bulletin of the old Mond Nickel Company, various pamphlets of the Aluminum Company of America, the New Jersey Zinc Company's Research Bulletin, etc. We have been commenting on the data in some of these bulletins in our book reviews, correlated abstracts, or ordinary abstracts, but it looks as though we should soon have to run a special department under some such heading as "Scientific Data from Commercial Research Departments" to deal with this new class of literature that is sent out gratis but is worth having.

There is a certain psychology by which the recipient of such literature gives the firm that puts it out a bit more credit than he would if it came to him as a reprint from the proceedings of a technical society. He files it under the firm name, and it impresses upon him that those people are getting and disseminating real facts. If the same material appears in a "house organ" together with a lot of vague propaganda it doesn't make the same impression, and is likely to go into the waste basket.

One such bit of literature in mimeographed form which has recently reached us is Technical Bulletin "B"—The Hot Acid Etch Test for Tool Steel, put out by the Research Department of the Carpenter Steel Company, Reading, Pennsylvania.

This doesn't say a word about Carpenter products. It doesn't emphasize that Carpenter steel is so tested, and doesn't mention the Diok (disc O. K. by etch test) trademark. That is left for their advertisements. The subtle idea is that the reader will feel that a firm which tells its customers just how to make a searching test for quality and points out the defects that are shown up by it, must be anxious to have its products put to such a test. We think this a powerful type of advertising.

The bulletin tells just what apparatus is required, just how the test should be conducted, shows illustrations of characteristic defects and gives pertinent comments on the interpretation of the results and their correlation with service.

Our readers might well invest a few stamps in asking to be put on the mailing list for publications of this sort from the various firms which provide them.

Readers' Views and Comments

Casting a Bronze Sleeve on a Steel Shaft

To the EDITOR of METALS & ALLOYS:

Dear Sir: I have below described the casting of a bronze sleeve on a steel shaft, which I hope your readers will find of value.

Fig. 1 shows the drag half of the mold with the shaft and the drag half of the pattern. Notice the blocks at the ends of the shaft to guide the shaft into place after being cleaned and tinned. Also notice that core sand has been used around and at the ends of the pattern.

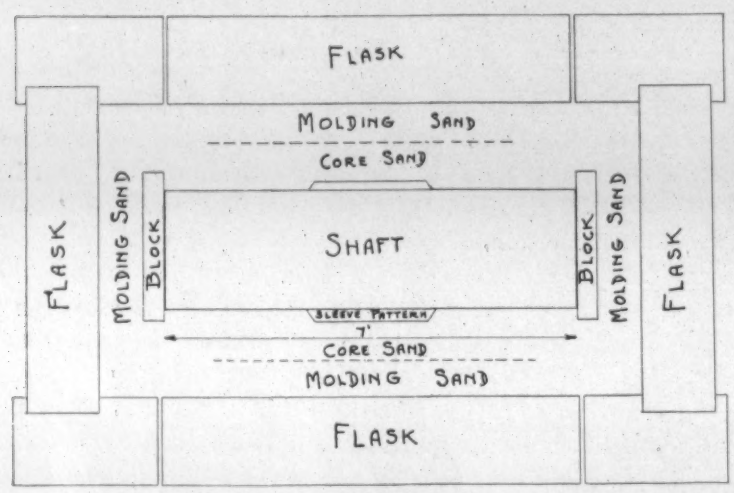


Fig. 1

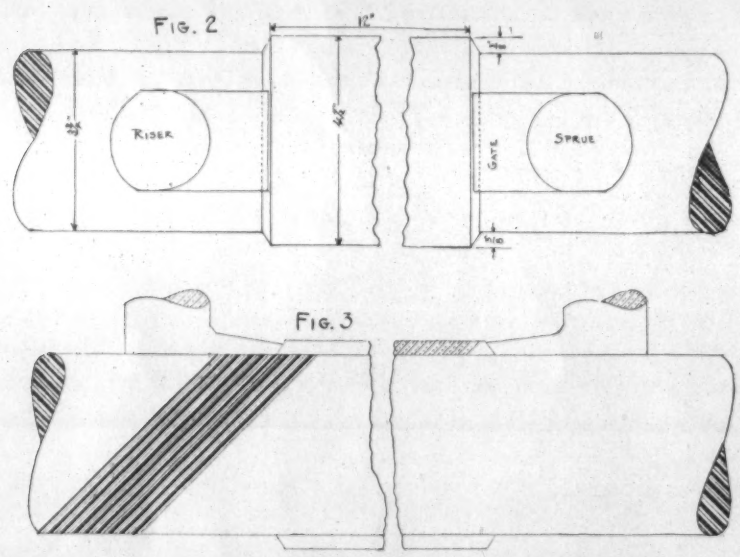


Fig. 2 is a top view, showing riser, gate and sprue. Fig. 3 shows a section through the center of the sprue, riser and shaft. Note riser and gate are about same size and shape.

The order called for casting a phosphor bronze sleeve 12″ long with a metal thickness of $^3/_8$″ on a 7′ steel shaft. The molding part of the job is simple. The shaft with the drag part of the pattern in place is bedded in as shown in Fig. 1. There should be at least 2″ of sand between the bottom board and pattern. The center of the shaft and pattern should be even with the flask joint, parting being made the cope part of the sleeve pattern is put on the shaft. Parting sand is thrown on and the cope put on the drag. Core sand is riddled on the pattern and shaft as far back as the riser and gate; bars are tucked, cope filled with sand, rammed-up and vented. After reaming riser and sprue, cut a channel from the riser toward the sides of flask large enough to hold 15–20 lbs. of metal. Lift the cope off the drag. When finishing it shave the mold at gate, riser and ends of pattern so there will be no danger of a crush. Do the same at ends and sides of pattern when finishing drag part of mold. When cope is finished, vent the drag by pushing the vent wire under the pattern from both sides of flask. Channels should be cut connecting vents, and if joints of flask fit so tight that the gas cannot escape, a $^1/_4$″ rod should be pushed through the cope.

After drawing the shaft from the drag, that part which will be covered by the molten metal should be cleaned and tinned or covered with solder. Sand blasting is a good way to clean it. The writer has found that an easy way to cover the shaft with solder, is to heat it until a bar of solder placed on it melts. It can be heated by placing it over a furnace or by using a torch. When heated it should be laid on horses so that it can be turned. Rub solder on shaft and use a scratch brush to spread it; continue doing this until the shaft is coated with solder, where the casting sprue and riser is to be. If the solder will not adhere to shaft, try soldering fluid or one of the pastes used on soldering jobs.

Spray the mold and skin, dry it when the metal is ready, heat the shaft if cold and put in mold. Place cope on drag, clamp and pour. Do not have the pot full, 70 or 80 lbs. in a No. 60 pot will be plenty. Have the stream of metal strike center of sprue and pour the metal as fast as the sprue will take it. Do not stop when metal shows in riser, but let it flow until riser and channels are filled, do not be in a hurry shaking out.

Points to remember: Cope should be vented thoroughly—not just a few jabs between bars; gate should be large; riser is to let air in mold escape quickly; metal, shaft and mold should be hot; have pot skimmed and keep sprue full—no dribbling.

JOSEPH P. MCGINNIS.

Syracuse, N. Y.

To the EDITOR of METALS & ALLOYS:

Dear Sir: It is evident that I made an error in my article in the January issue of METALS & ALLOYS in saying that Nichrome or high tungsten steel was used as the material for spark plug electrodes. Such a statement has been made in print but it would appear that this work was merely experimental, since the bulk of all spark plug electrodes consists of alloys containing more than 90% of nickel. I have checked this matter up with the makers of spark plugs and am glad to make this correction.

It is also stated in this article that propellers are made of forged magnesium. It is true that descriptions are given on "forged magnesium propellers" but these propellers, in accordance with information sent me by Mr. W. G. Harvey of the Aluminum Company of America, are made of magnesium with 4–7% of aluminum and about 0.4% of manganese.

BRADLEY STOUGHTON.

Lehigh University,
Bethlehem, Pa.

The Use of a Rubber Solution for Core Dipping

To the EDITOR of METALS & ALLOYS:

Dear Sir: Probably some of your readers will be interested in information on the use of a rubber solution for core dipping.

For two years the Detroit Lubricator Company has been experimenting in its brass foundry with the use of rubber solutions as core binders. This method was developed by the Metallurgical Division of the U. S. Bureau of Standards, working in cooperation with several rubber companies, and involves the substitution of a rubber solution for the linseed oil or other core binders commonly employed. Various forms of rubber in different solvents have been tried, as has also the "case hardening" process in which a weakly clay-bound core is coated with rubber to form a smooth, hardened shell. These experiments were interesting but, for a number of reasons, they did not result in our adoption of a rubber binder to replace the linseed oil we were already using.

Quite recently, however, an advantageous application of the method has been found. In a certain class of our castings we have to deal with cored holes of narrow cross section having inner recesses which are not accessible to machine tools. With these we have had trouble due to the fact that a considerable amount of core sand sticks to the metal in these passages and recesses and later causes trouble in service. Ordinary graphite core dips did not remedy this difficulty. An extra hand sand blasting operation removed most of the sand from the straight passages but could not reach the recesses.

After some experiment the difficulty was solved by using special cores made up from very fine waste sand-blast sand. These were mixed 100 parts of sand to one part of linseed oil and, after baking in the usual manner, were dipped in a solution of thermoprene cement, one part of cement to four parts of gasoline. The resulting cores were very smooth and, after casting, it was found that the metal in the cored passages was smooth and entirely free from adhering sand. The additional cost of the core dip was $0.16 per hundred castings but the special sand blasting operation, which had cost $0.35 per hundred, was eliminated so that, in addition to making a better product, the use of the rubber dip resulted in a net saving of $0.19 per hundred castings.

H. M. ST. JOHN.

Detroit, Mich.

Form of Furnace for Heat Treatment

By Robert M. Keeney*

In quality production at a low overall cost of finished product the form of furnace is of the greatest importance. It influences both the quality and the overall cost of the finished product. By the expression form of furnace is meant not simply its shape but the complete equipment for heating for heat treatment. It involves both design for and application to the specific operation under consideration. Form of furnace affects materially most of the factors involved in the production of a uniformly heated product—the essential of quality production.

This is one of a series of articles on the fundamental principles that underlie industrial heating operations. These are to be followed by articles on specific heat-treating operations, describing the metallurgical requirements and how to meet them.

The point of view in these articles is that of the user of furnaces who is interested in facts whose application will result in a better product and a lower over-all cost. Such articles are a refreshing change from the many articles in current literature which blow the trumpet about one particular type or make of furnace.

It influences:

(1) Uniformity of chamber temperature.
(2) Manner of heat application to the charge.
(3) Rate of heating.
(4) Time of exposure.
(5) Temperature control.
(6) Atmosphere of furnace.

Effect on Uniformity of Chamber Temperature

Uniformity of chamber temperature depends upon the design of the furnace and method of heat utilization whether a fuel or electricity is the source of heat. To obtain relative uniformity of chamber temperature in the combustion furnace, the correct method of firing must be used, and the furnace designed with a suitable number of burners and a carefully planned flue system. In the electric furnace, relative uniformity of chamber temperature results from the proper distribution of heating elements on the walls, beneath the hearth or on the roof, as seems best for the application under consideration. Uniformity of chamber temperature depends on the designer of the furnace, not on the source of heat. With proper design relative uniformity may be obtained with wood, coal, oil, gas or electricity, as the sources of heat, but it requires more skillful design and more trouble must be gone to, to obtain relative uniformity of chamber temperature with some sources of heat than with others. For example, it takes far greater skill to design a wood fired furnace having relative uniformity of chamber temperature, than to get the same result in an electric furnace.

In practice wide variations in uniformity of chamber temperature are often observed, so wide that many furnaces do not meet the requirement of even relative uniformity. The fact that this condition may exist regardless of the source of heat indicates clearly that relative uniformity of chamber temperature depends upon the form of furnace and not upon the source of heat. In poorly designed furnaces of the box type there may be a variation[1] of as much as 200° F. in different parts of a furnace operating at carburizing temperature. The average standard box type furnace will probably show the variations in chamber temperature mentioned in discussing uniformity of heat application, that is from 35-60° F., when operating at from 1500-1600° F. It is an extremely well-designed furnace that has no greater variation in chamber temperature than 20° F., probably one rarely found in practice. Seldom is the uniformity of chamber temperature equal to that obtained by Howe, Foley and Winlock[2] in their research on the influence of temperature, time and rate of cooling on the physical properties of carbon steel. In a furnace 7 in. in diameter by 14 in. deep, the variation in temperature was as follows: At 1430° F., variation 14° F.; at 1480° F., variation 13° F.; at 1525° F., variation 11° F.; and at 1570° F., variation 9°F.

From the experimental results of Mawhinney,[3] Fig. 1, it is apparent that the method of firing influences the uniformity of chamber temperature in a box type combustion furnace materially. In general, direct firing should not be used at temperatures below 1900° F., but is the only method of firing suitable at higher temperatures, not because of greater uniformity, but because of the limitations imposed by decrease of strength of refractories in the side and under firing methods. With side firing, although the bridge wall shields the heating chamber from the heat of combustion of the fuel, the hot gases enter the chamber at the top as in

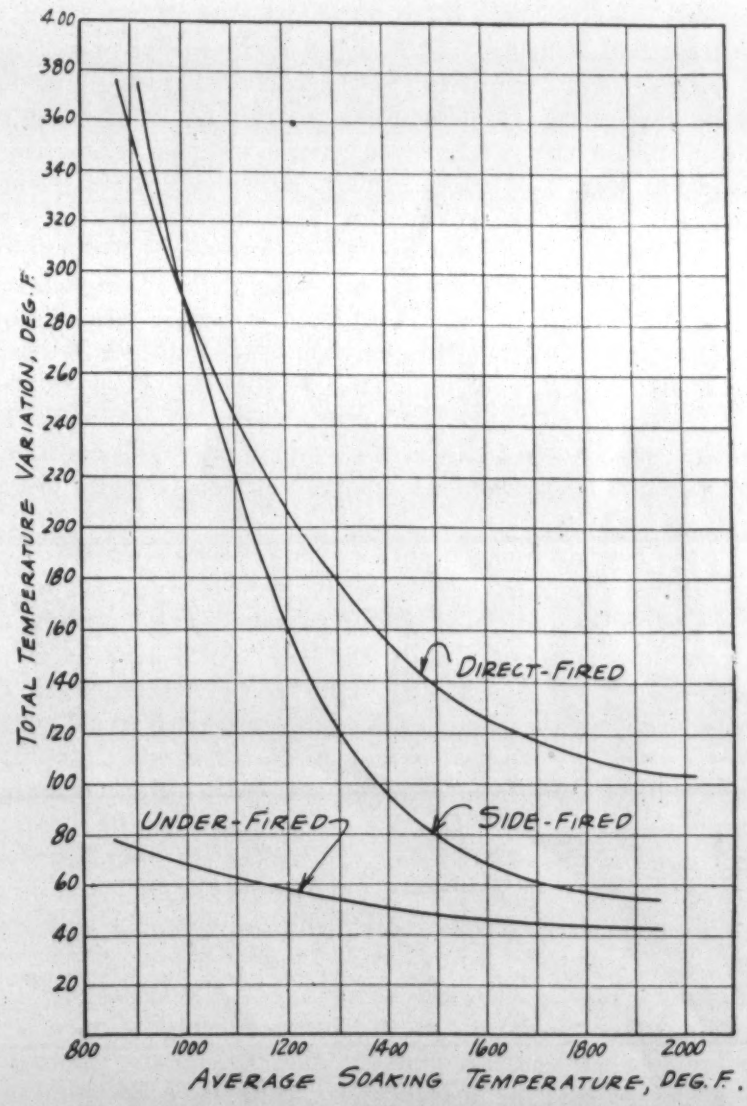


Fig. 1—Effect of Temperature on Temperature Control with Different Forms of Furnaces (Empty Furnace). (*Mawhinney*)

* The Connecticut Light and Power Company, Hartford, Connecticut.

[1] E. F. Davis, "Metallurgical Problems of Transmission Gearing," *Transactions American Society Steel Treating*, Vol. XIV, Dec. 1928, page 831.

[2] Henry M. Howe, F. B. Foley and J. Winlock, "Influence of Temperature, Time and Rate of Cooling on Physical Properties of Carbon Steel," *Transactions American Institute Mining and Metallurgical Engineers*, Vol. LXIX, 1923, page 722.

[3] M. H. Mawhinney, "Temperature Distribution in Combustion Furnace," presented at Cleveland Meeting, American Society Mechanical Engineers, Sept. 11, 1929.

direct firing, and with both methods, it is difficult to obtain uniform temperature[4] distribution between the top and the bottom. From the temperature variation shown in Fig. 1, with side firing, one might hesitate to use this method for temperatures below 1400° F. With under firing the greatest uniformity of chamber temperature results, Fig. 1, with the vertical[4] variation in temperature much lower than either direct or side firing, but the method is limited to temperatures below 1800° F. in the heating chamber, to avoid excessive temperature in the combustion chamber. For heavy loads on the hearth, the method should not be used for temperatures exceeding 1500° F. in the heating chamber. Under firing can not be satisfactorily applied to car type furnaces, and its application to continuous furnaces, except the pusher type, is limited. In the tests the maximum uniformity of heating chamber temperature possible was not obtained, because the port areas were made uniform to obtain the worst conditions, whereas, to secure the greatest uniformity the ports must be larger at the burner side to counteract the velocity of flames from the burner.

Mawhinney concludes: "Variations in furnace width can be fairly well taken care of by firing from one or both sides of the furnace, and for any method of firing—the horizontal variation will usually not be as great as the variations caused by the height of the furnace. The horizontal variation in a properly designed furnace of any width should be controllable to within 50° F. across the width for any method of firing. The height of the furnace is a much more serious factor in temperature control than is the width. With the bridge wall located in a position about 34 in. above the hearth of the test furnace with side firing, the vertical variation was 256° F. at 1020° F. average temperature, compared to 10° F. horizontal variation and at 1624° F., the vertical and horizontal variations were 42° F. and 13° F. Vertical control of temperature within 75° F. maximum variation for side firing and 150° F. for direct firing is obtainable with burners or bridge wall located up to 5 ft. above the hearth and furnace temperatures to 1600° F. or greater. For under firing the variation will be less. These values are based upon an empty furnace for 'soaking' conditions, and will be slightly reduced when a charge is properly placed in the furnace."

In the electric furnace no combustion takes place so that the following factors which must be considered in the design of the relatively uniformly heated chamber of the combustion furnace do not enter into the problem: intense flame temperature, flame velocity, high velocity of gases, draft, pressure within the chamber, bridge walls, port areas, vents, flues or the mechanical strength of refractories at high temperatures. In the electric furnace operating at a chamber temperature of 1500° F., the temperature of the heating element is only 100–150° F. higher than the chamber temperature so that the problems which arise from high flame temperature do not exist. Relative uniformity of chamber temperature in the electric furnace largely depends upon the arrangement of the heating elements in the chamber, the uniformity of insulation of the furnace, elimination of excessive loss of heat at spots in the furnace by "through metal loss," that is, loss of heat through conduction by parts of the furnace structure which may project into the chamber, and elimination of an excessive door loss. With so few variables involved compared with the combustion furnace, it is surprising that the uniformity of chamber temperature in box type electric furnaces does not more often approach that attained in the tests of Howe, Foley and Winlock, a variation of 9° F. at 1570° F.

From tests to determine temperature distribution in both combustion[3] and electric furnaces[2,4] and from Fig. 1, it is obvious that uniformity of chamber temperature decreases with the working temperature, that is, for a furnace of the box type, the variation of chamber temperature is greater when operated at a low temperature than when at a high temperature. This condition exists regardless of the source of heat. For this reason, care must be used in determination of the form of furnace and method of heat application for low temperature heat treating operations, such as the tempering of steel. Fig. 1 shows the effect of temperature on temperature distribution in combustion furnaces. Clearly with the direct fired and side fired furnaces having temperature variations of 370° F. at a working temperature of 900° F. neither of these methods of firing can be used for tempering nor would quality production result from a box type electric furnace designed for carburizing[4] and having a variation of 190° F. at a working temperature of 1200° F.

The uniformity of chamber temperature in a box type furnace is dependent mainly on the form of furnace, that is, the design and construction of the furnace. While unskillful operation of a combustion furnace may destroy the uniformity of chamber temperature of a correct form of furnace, the most skillful operation probably will not produce uniformity of chamber temperature in an improperly designed furnace. Unskillful operation of the electric furnace cannot destroy the uniformity of chamber temperature, as there can be no manual manipulation of the heat supply as in a burner nor can skilled operation produce uniformity in an incorrectly designed electric furnace. Therefore, extreme care should be exercised, when selecting the form of furnace either with fuel or electricity as the source of heat to be certain that the inherent characteristic of the forms of furnace under consideration are such as to result in the desired degree of uniformity of chamber temperature with skillful operation.

Effect on Manner of Heat Application to the Charge

To obtain a uniformly heated product the correct form of furnace for suitable application of heat to the charge must be available to the heat treater, but even with the correct form of furnace improper loading may result in failure to produce a uniformly heated product. This is true whether the source of heat be a fuel or electricity and is illustrated by the localized heating and deformation of die blocks when not loaded—"so as to expose the maximum surface area." Of course, the ideal method of heating would be suspension of the charge in the atmosphere of a uniformly heated chamber, but from a practical standpoint this is rarely possible, so that the charge must be supported from below. If the charge rests on the furnace bottom it is at once evident that the exposed surfaces will absorb heat at a different rate than the bottom surface, and another compromise between theory and practice occurs. In a box type furnace heated by combustion with either direct firing or side firing, or in a box type electric furnace having no heating elements in the hearth, it is obvious that the charge will not heat uniformly even if relative uniformity of chamber temperature exists, because there is no heat applied to the bottom of the charge. In practice the situation may be partially improved by raising the charge on a platform to permit convection heating below it. The value of bottom heating is now generally recognized, and it is used in most forms of furnaces where the type of furnace, temperature and mechanical considerations permit its use.

While heating of the charge in batches in a box type furnace is undoubtedly the logical solution of heating for heat treatment in many situations where the piece to be heated is large or of a great weight of the daily production of small pieces is to be varied in shape or too small in number to make the use of a continuous furnace practical from an operating and economic standpoint, there are probably many applications on which batch furnaces are in use where a continuous furnace would result in unexpected overall economies due to the production of a more uniformly heated product. A possible example of this is the annealing of brass tubing for drawing. For many years it has been

[4] *Metals & Alloys*, Vol. 1, May 1930, page 508.

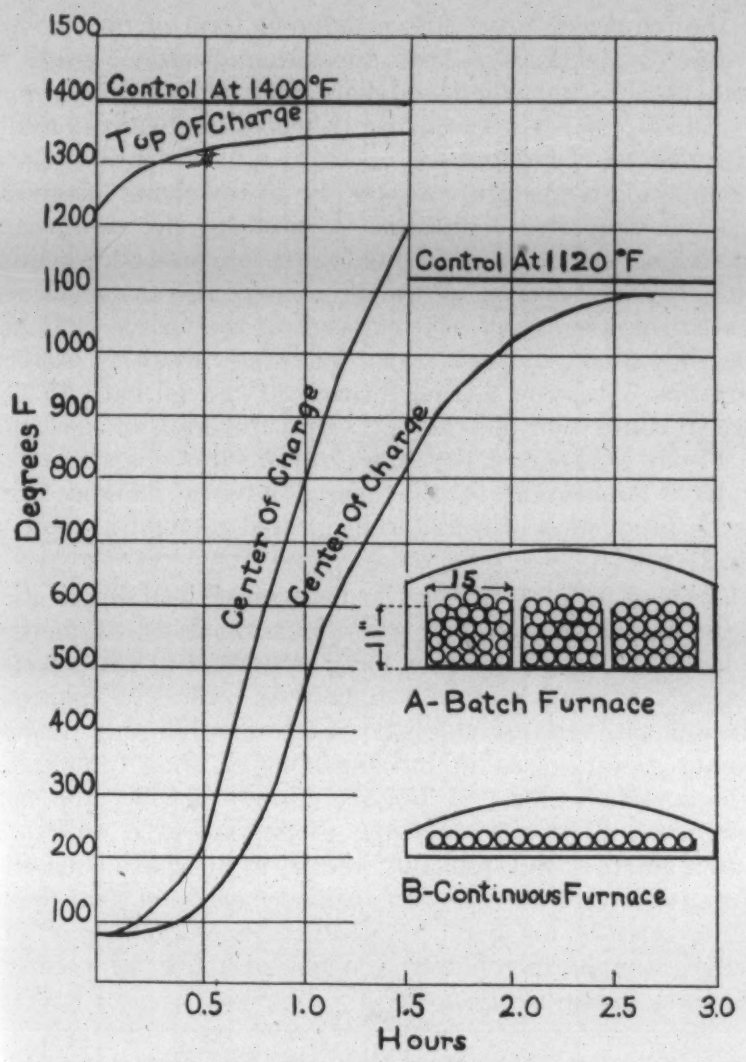


Fig. 2—Effect of Batch Form of Furnace for Annealing Brass Tubing on Uniformity of Heating of Charge

customary to anneal brass tubing by placing it in U-shaped racks which are loaded on a pan and pushed into the furnace as shown in Fig. 2 "A." It is apparent that with this method of application of the heat to the individual tube, the outside tubes are going to be heated much more rapidly than the inside tubes, and consequently will remain at the chamber temperature for a much greater length of time than the inner tubes, unless the furnace and charge are brought to temperature together. Fig. 2 shows the rate of heat penetration to the center of a charge of yellow brass tubing, 0.3125 in. diameter, 0.028 gage, piled in racks so that each pile was 11 in. high and 15 in. wide, at two chamber temperatures, 1120° F. and 1400° F. Taking two hours and 40 minutes for the center tubes to reach 1100° F., with a chamber temperature of 1120° F., means that the outer tubes are probably held at 1100° F.—two hours longer than the inner tubes. While it is possibly true that for the purpose intended, drawing, this condition in the anneal probably results in no injury to the quality of the tubes, which would not be rectified in the finishing anneal; it is an excellent example of un-uniformity of heat application and of a failure in practice to produce a uniformly heated product. In Fig. 2 it will also be noted that the rate of heat penetration is increased over 40% by the increase in chamber temperature of 280° F. from 1120–1400° F., and that with a chamber temperature of 1400° F. the outside of the pile of tubing never exceeded 1345° F., a difference of 55° F., another example of the fact that the chamber temperature indicated by the control pyrometer is not necessarily an indication of the temperature of charge. To the tube drawer, the long soaking period of one hour and 30 min. to two hours and 40 minutes necessary to bring the center of the charge to its outside temperature is impractical, so a compromise is made. It has been found that yellow brass tubing draws satisfactorily, based on present standards, in the rather wide range of temperature between 1000° F. and 1350° F. The chamber temperature is maintained at 1350° F., and a charge is heated for about one hour, a period, which experience and test have shown to be sufficient for the center tubes to reach a temperature of 1000° F. Most of these tubes have been annealed at different temperatures, between 1000° F. and 1350° F. A uniformly heated product has not been produced as would be the case if the furnace was loaded as shown in Fig. 2 "B," a method readily adapted to continuous production if the required output is sufficiently large.

The effect of this wide variation in temperature on the hardness and grain size of cartridge brass is indicated by the research of Bassett and Davis,[5] Fig. 3. At an annealing

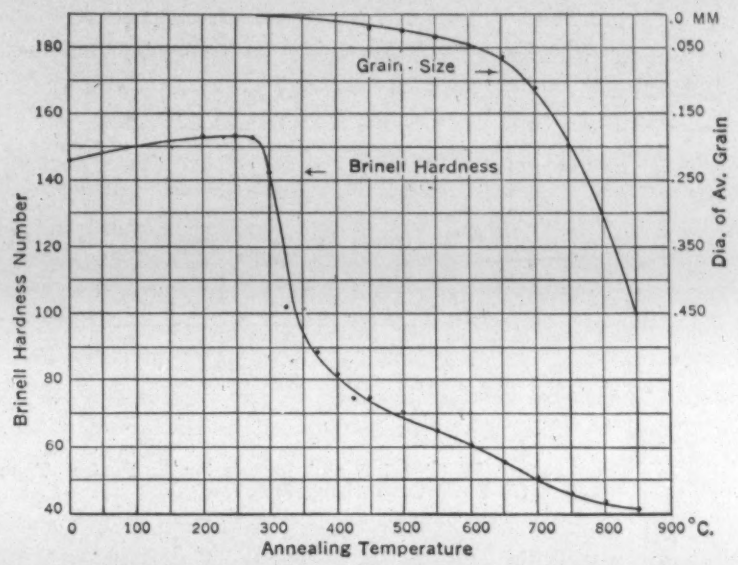


Fig. 3—Effect of Annealing Temperature on Brinell Hardness and Grain Size of 0.376 in. Gage Cartridge Being Previously Reduced 35.1% by Rolling. (*Bassett and Davis*)

temperature of 1000° F. (538° C.) the Brinell hardness is 68, but at an annealing temperature of 1350° F. (732° C.) it is 48, a decrease of about 30%. The grain size, however, has increased 400% from 0.03 mm.–0.15 mm. With this condition existing it means from a practical standpoint that the draw benches work at the rate established by the tube annealed at 1000° F. with a Brinell hardness of 68, or if an attempt is made to keep up the pace set by the tube with a Brinell hardness of 48, die trouble and other difficulties may result. The production of an un-uniformly heated product, resulting from the form of furnace, has probably increased the over-all cost of the finished product. The correct form of furnace, a continuous furnace with correct loading, Fig. 2 "B," would result in the production of a more uniformly heated product, probably at a lower over-all cost.

The condition resulting in the batch annealing of tubing is also found in other heat treating operations involving heating a large number of small pieces, and its recognition has resulted in the development of continuous or semi-continuous furnaces in which heat is applied more uniformly to the individual piece than in the batch method of heating. In the continuous form of furnace three of the essentials of a uniformly heated product are combined: (1) application of heat uniformly to the individual piece; (2) proper rate of heating to the correct temperature; and (3) time at temperature. In the continuous form of furnace uniformity of chamber temperature does not have the same meaning on the box type furnace. Individual pieces are being heated, not batches, so that in the continuous form of furnace, uniformity of temperature is really necessary only across the horizontal width of the furnace conveyor to a height slightly above the top of the individual piece. The charge is not stacked, nor does the individual piece remain in one spot, which in a box type furnace may or may not be at the same temperature as other parts of the chamber. Entering the furnace cold, each individual piece of the charge is gradually heated to the same temperature, at the same rate, held at temperature for the same time and discharged just as if it were the only piece in the furnace, provided there

[5] W. H. Bassett and C. H. Davis, "A Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass," *Transactions American Institute Mining & Metallurgical Engineers*, Vol. 60, 1919, page 428.

exists uniform temperature distribution across the width of the chamber to above the height of the piece. Longitudinal temperature distribution is of no concern, and the necessity of vertical uniformity, the most difficult to obtain, has been virtually eliminated. In brief, uniformity of chamber temperature in a continuous furnace means mainly horizontal uniformity. One problem of furnace design has been simplified. Of course, in a semi-continuous pusher type furnace, longitudinal uniformity of temperature distribution is essential in the soaking zone as shown in Fig. 4,

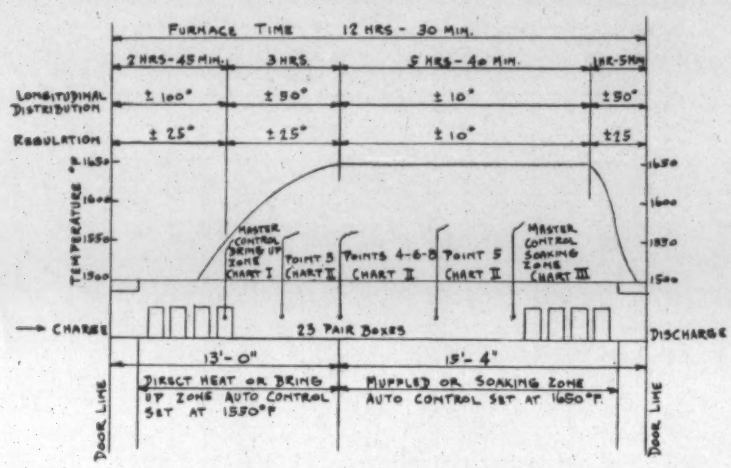


Fig. 4—Temperature Distribution and Regulation in Pusher Type Oil-Fired Carburizing Furnace

which is a summary[6] chart of temperature distribution and temperature regulation in an oil fired carburizing furnace having inside dimensions 25 ft. long, 4 ft. wide and 22 in. high. The carburizing boxes were pushed through the furnace in two rows in the same direction. It will be noted that in the soaking zone of this oil fired furnace, both longitudinal distribution of temperature and temperature regulation had an extreme variation of only 20° F. Tests made on the vertical temperature distribution showed no discernible difference from a point two inches above the hearth to about two inches above the top of the boxes. Determination of the inside temperature of four successive boxes showed a temperature of 1610° F. in each case, or 40° F. below the chamber temperature of 1650° F., but well above the minimum quenching temperature of 1550° F., so that a uniformly heated product was being produced.

With uniformity of heat application to the individual piece, rate of heating and time at temperature all under control in the continuous form of furnace, the probability of production of a uniformly heated product is much increased. Determination of its field of usefulness involves consideration of the size and shape of the pieces to be heated and the quantity and regularity of production. Depending on the form of continuous furnace, their economic application usually involves a considerable production and operation of the furnace at capacity. With the wide use of heat resisting alloys in furnace construction during recent years, the development of continuous forms of furnaces to which any liquid or gaseous source of heat or electricity may be applied, has been much accelerated.

Due to difficulty in securing relative uniformity of chamber temperature as the working temperature decreases and with ample evidence of the sluggishness of heat transfer at low temperatures, careful consideration should be given to the form of furnace and method of heat application to the charge in tempering. In the tempering range of carbon steels from 350–600° F., Table I, depending on the objective

Table I—Tempering Temperatures of Carbon Steel
(Recommended Practice A. S. S. T.)

Result Desired	Temperature
Relieving strains	350–375° F.
Relieving strains and reducing brittleness	400–500° F.
To relieve strains and to toughen	500–600° F.

[6] A. E. White and E. R. McPherson, "An Efficient Carburizing Furnace of the Surface Combustion Type," *Transactions American Society Steel Treating*, Vol. 10, Dec. 1926, page 941.

of the tempering operation, a different form of furnace and a different method of heat application probably must be used than in annealing and hardening at temperatures of from 1380–1550° F., if a uniformly heated product is to result. The degree of uniformity of temperature distribution at a tempering temperature of 500° F., in the charge of several types of tempering equipment—a box type electric furnace, an oil bath and a furnace using forced convection air heating with frequent reversals of the direction of the air, which was heated by a source of heat external to the charge chamber, was investigated with the following results: extreme variation, box type electric furnace 30° F., oil bath 15° F., forced convection air heating with reversal of direction 3° F. It is apparent that the form of furnace and method of heat application to the charge have a marked effect on the production of a uniformly heated product in tempering.

Form of furnace affects the manner of heat application to the individual piece and is closely associated with method of loading: (1) if a proper form of furnace is not selected incorrect loading naturally follows in order to maintain output, with the production of an un-uniformly heated product resulting, as in the annealing of brass tubing, (2) with a suitable form of furnace, correct loading methods probably will be used and the production of a uniformly heated product will probably result, as in continuous furnaces, and (3) a form of furnace and method of heat application suitable for high temperature operations may not produce a uniformly heated product in a low temperature process as in tempering.

Effect on Rate of Heating, Time of Exposure, Temperature Control and Atmosphere of Furnace

Although rate of heating and time of exposure depend mainly on the operator and supervision, the form of furnace sometimes imposes limitations, because of improper design for the application. Furnaces are sometimes observed in use on work requiring slow application of heat to the charge, which are not sufficiently flexible in the control of the source of heat, to permit slow heating without continuous hand operation of the control. It might be difficult to obtain the correct time at temperature in a continuous furnace because of lack of flexibility in the speed control of the conveyor mechanism as in a semi-continuous furnace because of the wrong length or arrangement of the heating zones.

The form of furnace or incorrect method of heat application used for a heat treating operation may completely upset the effect of automatic temperature control due to overshooting of the control temperature in parts of the charge, as shown in Fig. 5, which shows the lack of uniformity throughout a charge being tempered at 475° F. in an electric box type furnace. The same condition would result in varying degrees regardless of the source of heat when any box type furnace is used for tempering. A similar condition sometimes exists in heating for quenching in a lead bath, if it is built with too great a quantity of fire-brick in its heating chamber so that even after the source of heat has been turned off by the automatic control, functioning through a thermocouple immersed in the lead, the fire-brick lining gives off such a large quantity of heat that the temperature of the bath continues to rise, and may even overshoot the control temperature as much as 50° F. The situation is the result of using too much fire-brick in the furnace chamber, and may be improved by using a thin wall of fire-brick or instead of fire-brick, a wall made of light semi-refractory insulating brick. The temperature control is also improved by controlling the source of heat both from the lead bath and from furnace chamber with a thermocouple in each.

The incorrect form of furnace may thus handicap skilled supervision and operation in the production of a uniformly

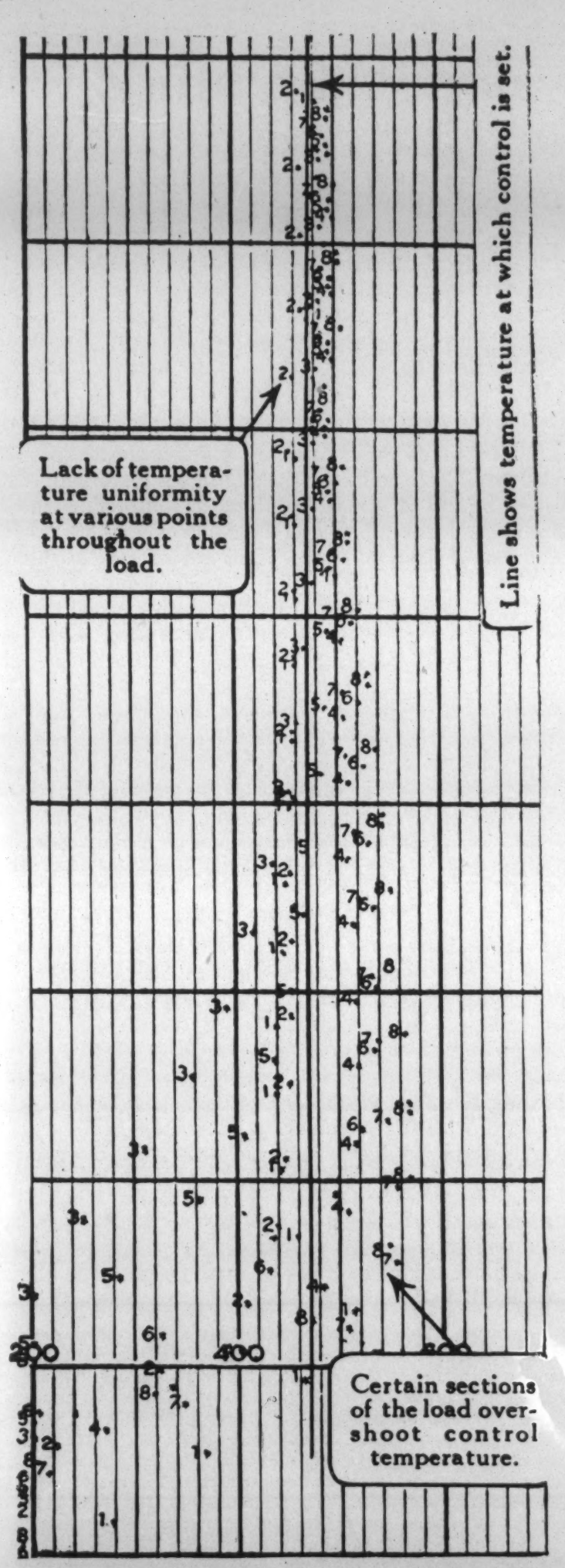

Lack of temperature uniformity at various points throughout the load.
Line shows temperature at which control is set.
Certain sections of the load overshoot control temperature.
400
800

Fig. 5—Direct Method of Application of Heat to the Charge in Tempering, Causes Section to Overshoot Control Temperature. (*White and McPherson*)

heated product, by its lack of flexibility not permitting the proper rate of heating and time at temperature, and by its wrong method of heat application and incorrect design destroying the benefits of temperature control.

Although the atmosphere of the furnace chamber is largely dependent on the source of heat or on the creation of an artificial furnace atmosphere through external means, in some cases the production of a suitable furnace atmosphere requires a suitable form of furnace, as in the water sealed furnace for bright annealing copper.

Influence on Over-all Costs

The form of furnace has a marked influence on over-all costs just as on the factors involved in the production of a uniformly heated product. Often savings in over-all costs which are credited to the source of heat are really due to the form of furnace. The form of furnace affects the following items which enter into over-all costs: consumption of fuel or electricity, labor for heat treatment, maintenance, investment charges on equipment, quality and rejections, labor after heat treatment, capital charges on material in process and in storage and ease of operation.

The effect of form of furnace on the consumption of fuel or electricity and labor for heat treatment is shown in Table II. The majority of the cases cited are the results obtained in the same plants on the same work with the same source of heat, but with different forms of furnaces. The comparisons are made merely to show the effect of form of furnace on heating and labor costs under the local conditions involved in each case and in no way are to be considered as a comparison of cost of heat treating with different sources of heat because over-all costs are not shown.

In example No. 1, the use of a counterflow furnace reduced the power cost 40%, for annealing brass shells. The power cost was 140% higher and labor cost 100% greater when annealing brass tubing in a water sealed furnace instead of a box type furnace, No. 2. As brass tubing after annealing in a water sealed furnace must be pickled just as it would be after annealing in a box furnace, the use of a water sealed furnace for this application must be considered as a case of incorrect form of furnace. For annealing nickel silver, with either gas, No. 3 or electricity, No. 4 as the source of heat, the use of the continuous belt furnace instead of a pusher furnace, reduced heating costs 28% because of the elimination of pans. The consumption of oil for annealing steel forgings was reduced 91% and labor cost cut 75% by the use of a pusher furnace instead of a box furnace in plant No. 5. The oil cost for carburizing in Plant No. 7 was \$16.50 per ton of work lower or 83% less, after a pusher type furnace was substituted for a box furnace. In heating for hardening the use of continuous conveyor furnace saved 33% in oil consumption as compared with the box furnace and \$6.00 per ton or 80% in labor cost, No. 8. By use of a rotary drum gas furnace instead of a box gas furnace the gas consumption was increased 100%, but on the particular application, No. 9, the over-all cost with the rotary drum furnace was less than with the box furnace because of the production of a more uniformly heated product. From these few examples it is evident that the form of furnace is a deciding factor in the consumption of fuel or electricity and labor required, and that this condition holds regardless of the source of heat.

The cost of heating is also affected by the design of furnace with reference to thermal efficiency and adaptability to the specific application. All furnaces should be insulated to assist in obtaining uniformity of chamber temperature, but the quantity of insulation is an economic problem depending on the rate of return on the increased investment resulting from heavier insulation. On furnaces to be used for short hours of operation or intermittent operation, the cost of heating is less if the quantity of heavy, refractory brick is limited as much as is commensurate with physical strength, to avoid a large consumption of fuel or electricity by absorption in the walls. A thin wall of refractory brick, backed up by semi-refractory insulating brick results in a lower heating cost in such cases.

Maintenance expense varies with the form of furnace, the materials used in the construction, the skillfulness of design, the alloys used and also depends to a considerable extent on the source of heat and its method of application. A simple box type furnace naturally has less maintenance expense than a continuous furnace but the lower labor cost

Table II—Effect of Form of Furnace on Heat and Labor Costs

No.	Heat Treating Process	Source of Heat	Type of Furnace	Consumption per Ton of Work	Cost per Ton	Man Hours per Ton	Labor Cost per Ton
1	Annealing brass shells	Electricity	Box	142 kw.-hr.	$1.56		
"	" "	"	Counterflow	76 "	0.84		
2	Annealing brass tubing	Electricity	Box	84 "	1.42	1.5	$0.75
"	" "	"	Vertical water seal	200 "	3.40	3.0	1.50
3	Annealing nickel silver	530 B.t.u. gas	Pusher	3,900 cu. ft.	3.51	2.5	1.25
"	" "	"	Continuous belt	2,800 " "	2.52	2.5	1.25
4	Annealing nickel silver	Electricity	Pusher	200 kw.-hr.	3.50	2.5	1.25
"	" "	"	Continuous belt	145 "	2.53	2.5	1.25
5	Annealing steel forgings	Oil	Box	108 gal.	6.48	12.0	6.00
"	" "	"	Pusher	9 "	0.54	3.0	1.50
6	Annealing steel sheets	Electricity	Car	250 kw.-hr.	3.00		
"	" "	"	Continuous	200 " "	2.40		
7	Carburizing steel	Oil	Box	330 gal	19.80		
"	"	"	Pusher	55 "	3.30		
8	Hardening steel	Oil	Box	30 "	1.80	15.0	7.50
"	"	"	Continuous conveyor	20 "	1.20	3.0	1.50
9	Hardening steel	Gas	Box	5,300 cu. ft.	5.30		
"	"	"	Rotary drum	10,700 " "	10.70		
10	Hardening steel	Electricity	Box	250 kw.-hr	3.50	6.0	3.00
"	"	"	Continuous conveyor	250 "	3.50	3.0	1.50
"	"	"	Rotary hearth	200 "	2.80	2.0	1.00

and heating cost of the latter, generally much more than offset any higher maintenance expense.

There is a somewhat general impression that the furnace investment depends upon the source of heat. This is probably true for the box type furnace with the greatest investment in the electric furnace and the smallest in oil or coal fired furnace, but for large continuous furnaces the investment cost seems to depend upon the form of furnace and not upon the source of heat. Quotations recently made on continuous electric and gas furnaces of the same type were slightly higher for the gas furnace. Several years ago a large pusher type oil furnace was built at a cost about 10% greater than the quoted price on a similar electric furnace.

Through its influence on uniformity of chamber temperature and uniformity of heat application to the charge, the form of furnace affects quality and rejections, labor after heat treatment, and capital charges on material in process and in storage, in conjunction with skilled operations. The evaluation of a decrease in rejections is usually difficult, and can only be arrived at by a thorough investigation, but, of course, a decrease in rejections on inspection means less chance of losing business due to poor quality. The production of a uniformly heated product not only makes a saving in rejections, but also materially decreases the cost of labor and tools used for inspection. In one plant with a production of five tons per day, six dozen files costing $2.25 per doz. were used each day for testing each piece after hardening, at a cost of $2.70 per ton. With the installation of a furnace which produced a very uniformly heated product, it was possible to reduce inspection costs materially. The effect of a form of furnace resulting in the production of a uniformly annealed product, in a number of cases has resulted in a marked reduction in labor after heat treatment through its effect on machining costs by speeding up production, and also materially reduced the inventory of steel and finished product required in storage. Labor after heat treatment is also very considerably affected by the adaptability of the furnace to straight line production, because of the saving in the handling and cartage of the product from and to other departments. The ease of operation resulting from a suitable form of furnace equipped with automatic control, releases skilled supervision for planning and other productive work, sometimes permits the employment of less and lower priced labor and may have cleared up operating difficulties affecting the morale of the operating crew, thus reducing overall costs.

Form of furnace, that is its type, uniformity of chamber temperature, uniformity and method of heat application to the charge, control of flow of heat energy, thermal efficiency, labor requirements and ease of operation has as great an effect, possibly often the greatest effect, as any other factor in the production of a uniformly heated product at a low over-all cost. Having such a marked effect on the problem of heating for heat treatment, not only skill in design is essential, but mature judgment in selection is necessary if a uniformly heated product at a low over-all cost is to be obtained.

Production Nitriding Furnaces

The Westinghouse Electric & Manufacturing Company has developed two production nitriding furnaces of 1000 and 3500 pound capacities respectively. These furnaces embody the Bell type construction.

This furnace consists of a movable rectangular shaped bell, well insulated and equipped with heating elements around the sidewalls. With each furnace Bell two bases and two metal nitriding box containers are supplied. The bases are also equipped with heating elements to insure even heating of the charge. Crane facilities are necessary for the handling and transfer of furnace Bell.

The metal nitriding boxes are mounted on top of the bases and gas pipe connections are made permanently to each nitriding box. The boxes have a "V" shaped seal trough for lead or other soft metals into which fits a tapered seal lip on the cover. The cover is also clamped down by wedges, so that a proper seal can be effected before the lead is melted, to allow passing ammonia gases into the box to exhaust all of the air before the heat is turned on. The ammonia gases are fed into the bottom of the nitriding box through three separate gas distributing pipes. Since the ammonia gases break up into nitrogen and hydrogen gases, and as the latter is considerably lighter than the former, a greater portion of the hydrogen will be liberated through the gas outlet pipes. This means that the concentration of nitrogen gases will be greater than with other systems using a fan for circulation, as the fan keeps the nitrogen and hydrogen gases well mixed.

In operation the charge is loaded into the nitriding boxes and the cover is secured on tight, then the ammonia gases are turned on to exhaust the air. Better nitriding results can be obtained by having the box completely filled with ammonia gases before the cycle is started. When the heating or soaking cycle has been completed, the furnace Bell can be transferred to the second charge and base, allowing the first charge to cool in the nitriding box with gas connections still maintained to the ammonia gas supply. The economy of the Bell type of furnace is very high due to the fact that it is not necessary to leave the Bell portion of the furnace over the nitriding box during the cooling-cycle, and the heat absorbed in the Bell is maintained when transferred to the second base.

Corrections: "The Structure of Heat Treated Low Carbon Steel June METALS & ALLOYS."

Page 539, column 2, line 44 *from top.* This line reads of printed: "1300° F. (740° C.) and increasing by increments as 50—" It should read: "1300° F. (740° C.) and increasing by increments of 50° F. to"

Page 539, column 2, line 47 *from top.* "650° F." should read "65° F."

Page 539, column 2, lines 17 and 18 *from bottom.* These lines read as printed: "electric muffle furnace. The temperatures recorded are within ±50° F. of the actual temperatures." They should read: "electric muffle furnace. The temperatures recorded are within ±5° F. of the actual temperatures."

Some Elementary Facts about Cast Iron

By George M. Enos*

Introduction

In this article, as in previous articles,† it is the purpose of the author to correlate general principles from the various branches of science with foundry practice. It is desired to avoid not only detailed descriptions of foundry technique but also that part of theory which is largely speculative in nature. The material that follows is obviously gathered from many sources, and is intended to summarize the commonly accepted views on the metallography of cast iron. At the outset it may be stated that much of the theoretical information regarding the equilibria of iron with carbon, with silicon, with phosphorus and with other elements present in commercial cast iron has not been of much interest to the practical foundryman. This is because of the difficulties encountered in attempting to correlate differences in opinion, and discrepancies in data of the various investigators. In the nature of things, much data that is entirely reliable, cannot be applied directly in practice. This is because variables which are controlled in laboratory experimentation, can be controlled only with considerable difficulty or expense, or not at all, in foundry practice.

Commercial cast irons contain so many elements that the iron–carbon diagrams, i. e., the iron–iron carbide and the iron–graphite equilibrium diagrams, are useful only as an introduction to the general nature of cast irons. Indeed, authorities are not agreed on the exact placing of several of the important lines in the diagrams. For further consideration of this point, reference may be made to articles by Ellis,[1] Krynitsky,[2] Dowdell[3] and others, which have appeared recently in METALS & ALLOYS.

Relationships of Iron and Carbon in Cast Iron

Definitions.—*Cast iron* is an alloy of iron and carbon containing over 1.7% carbon which, as cast, cannot be worked at any temperature. Commercial cast irons vary widely in nature and composition and usually contain silicon as an essential ingredient, and phosphorus, manganese and sulphur. For purposes of discussion, cast irons may be grouped under three general heads, viz. white cast iron, gray cast iron and malleable cast iron. These may be defined as follows:

White Cast Iron.—A cast iron in which practically all of the carbon is in the combined form.

Gray Cast Iron.—Gray cast iron is characterized by the presence of graphitic carbon, in the "as cast" condition. Usually cementite is also present, but not necessarily so.

Malleable Cast Iron.—A cast iron in which the carbon appears mostly as graphite in a form known as "temper carbon." This condition is produced by the heat treatment (annealing) of white cast iron.

It is possible to obtain a cast iron containing both gray cast iron and white cast iron, known as "mottled cast iron." *High strength* cast irons, *pearlitic* cast irons, *alloy* cast irons, "*semi-steel*," and *pig iron* may all be considered as akin to gray cast iron, since they all have carbon present in both the graphitic and combined form.

The above definitions are admittedly incomplete. It will be noticed that distinctions between the three general types of cast iron are made on the basis of the condition of the carbon. Distinction between cast iron and steel is made upon the basis of workability, since some steels may contain over 1.7% carbon. The limits of carbon content in commercial cast irons and steels overlap in certain special cases, although, in general, steel does not contain over 1.5% carbon and cast iron does not contain less than 2.0% total carbon. The special cast irons such as semi-steel and alloy cast irons will be considered in another article.

While cast iron castings containing only iron and carbon are not produced commercially, still a brief consideration of the structures and properties of such alloys is in order, since the principal effect of the impurities or minor alloying elements is to modify the general conditions existing for the simple binary alloy.

Solubility—Relations.—The solubility of carbon in iron varies with temperature. In this discussion we are not concerned with exact melting point of iron, nor with the solubility relationships for the lower carbon values, i. e., steel. Differences of opinion exist as to exact values. (See Ellis.[1]) Based on work by Ruff and Goecke as discussed and illustrated by Sauveur[4] a diagram for the solubility of carbon in the cast iron range of iron-carbon alloys has been constructed. Fig. 1.

From this diagram, and other information, the following may be noted.

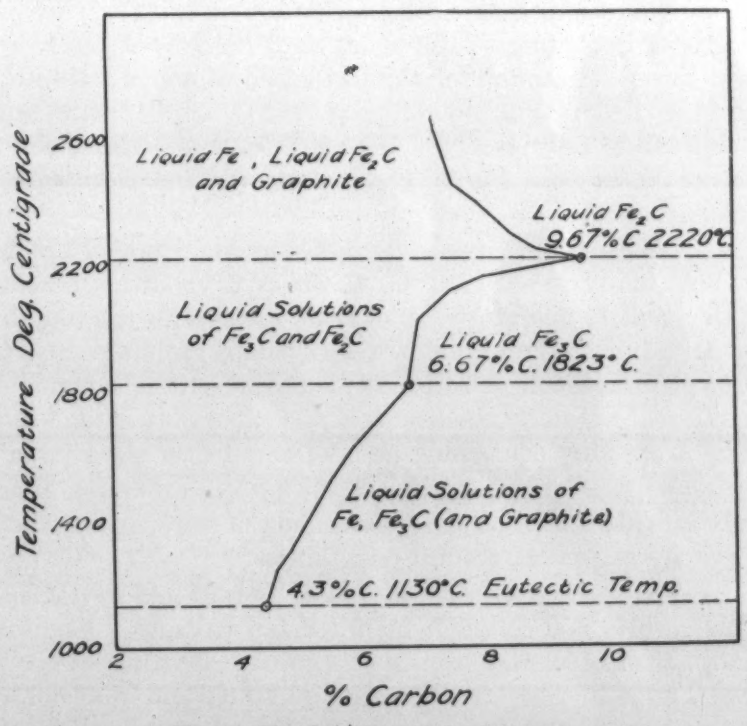


Fig. 1—The Solubility of Carbon in Iron

1. The iron-carbon diagrams, as usually published in textbooks, limit the carbon content of cast iron to 6.67% C, or less. (See Fig. 2 and Fig. 3). At very high temperatures more carbon may be dissolved.

2. The solubility of carbon in iron is not a straight line function of temperature but varies with the formation of the compounds Fe_2C, and Fe_3C and with the breakdown of these compounds.

3. Starting with a temperature of 2220° C., where the

* Assistant Professor of Metallurgy, University of Cincinnati.

† "The Flow of Metals in Molds," Part I, *Metals & Alloys*, February 1930, pages 362–364; Part II, March 1930, pages 417–419; and "Molding Sands," May 1930, pages 496–501.

[1] O. W. Ellis, "The Solidus of the Iron–Carbon System," *Metals & Alloys*, Vol. 1, April 1930, page 462.

[2] A. I. Krynitsky, "The Status of the Double Iron–Carbon Diagram," *Metals & Alloys*, Vol. 1, April 1930, page 465.

[3] R. L. Dowdell, "Phases of the Metastable Iron–Carbon Constitution Diagram," *Metals & Alloys*, Vol. 1, May 1930, page 515.

[4] A. Sauveur, "The Metallography and Heat Treatment of Iron and Steel," 3d ed., 1926, pages 360–361.

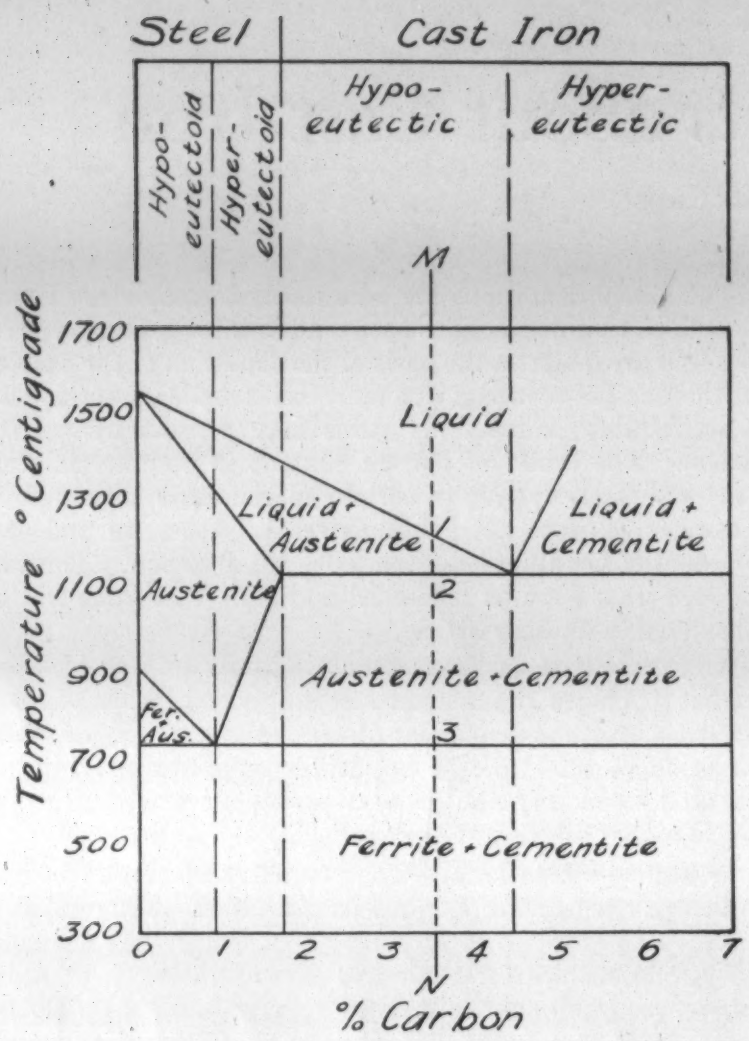


Fig. 2—The Equilibrium Diagram for the Iron–Cementite System. Based on the Diagram as Given in "The Science of Metals" by Jeffries and Archer. The line M-N with Its Numerals Is Added to Facilitate Discussion in the Text.

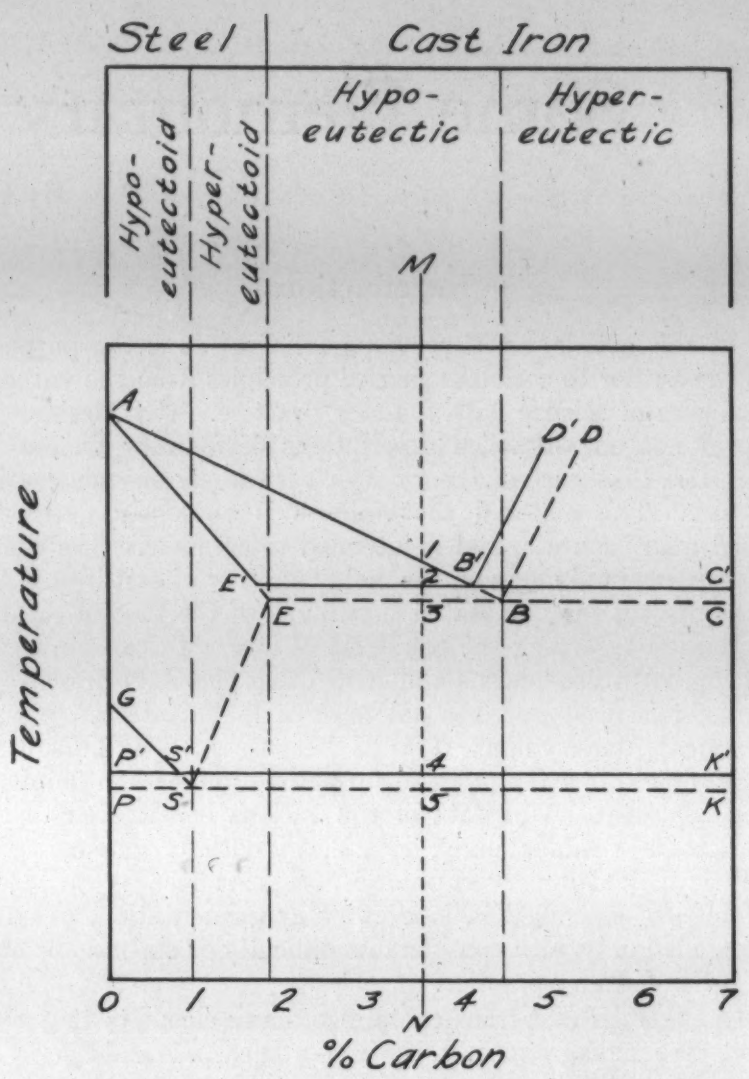


Fig. 3—The Equilibrium Diagram for the Iron–Graphite System. Based on the Diagram Given in "The Science of Metals" by Jeffries and Archer. The Dotted Lines Indicate the Corresponding Values in the Iron–Cementite System.

maximum amount of carbon is dissolved, above this temperature, some Fe_2C probably breaks up into iron and graphite, below this temperature, the formation of Fe_3C is favored, probably according to the equation $3\ Fe_2C = 2\ Fe_2C + C$, and this will account for the formation of some graphite on cooling, between 2220° C. and 1823° C. At the latter temperature only Fe_3C is present. Cooling further, the reaction $Fe_3C = 3\ Fe + C$ accounts for the formation of graphite.

4. Melting and casting temperatures in foundry practice do not usually exceed 1500° C., therefore the changes indicated above that temperature are of little interest to the foundryman, except as the solubility relationships are altered by the presence of silicon or other elements present in commercial cast irons. Usually conditions in the cupola favor the formation of an alloy containing about the eutectic percentage of carbon.

It is evident that on the slow cooling of iron-carbon alloys, there are several structural possibilities.

I. *The cast iron contains only ferrite and graphite.* This case is not common in untreated castings. Commercially, malleable cast iron may approximate this structure. (See Fig. 4.) The strength and ductility and malleability of this type of structure depends on the properties of the ferrite, and on the continuity or lack of continuity due to the form and distribution of the graphite.

II. *The cast iron contains only pearlite and cementite.* These irons are known as "hard castings," or as white cast iron (because of their typical white fracture). See Fig. 5 *a* and *b*. The structure in this case is analogous to that of a high carbon steel, and, of course, the castings are very hard and brittle and will not stand shock or impact.

III. *The cast iron contains both combined and graphitic carbon.*

a. The matrix is "hypo-eutectoid" and so consists of ferrite and pearlite.

b. The matrix is "eutectoid" and consists of pearlite. (See Fig. 6.)

c. The matrix is "hyper-eutectoid" and consists of pearlite and cementite.

d. The pearlite is so formed that the ferrite and cementite can be easily identified as separate constituents, hence the cast iron structurally consists of ferrite, cementite and graphite.

Cast Iron as a Steel.—Rosenhain[5] and others have pointed out that when a cast iron contains combined carbon, it

[5] W. Rosenhain, "Introduction to Physical Metallurgy," 2nd ed., 1919, page 187.

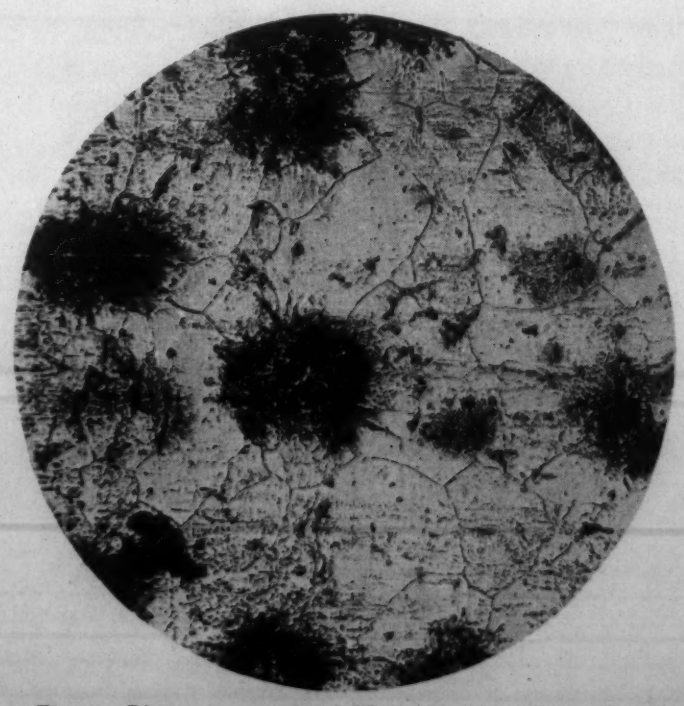
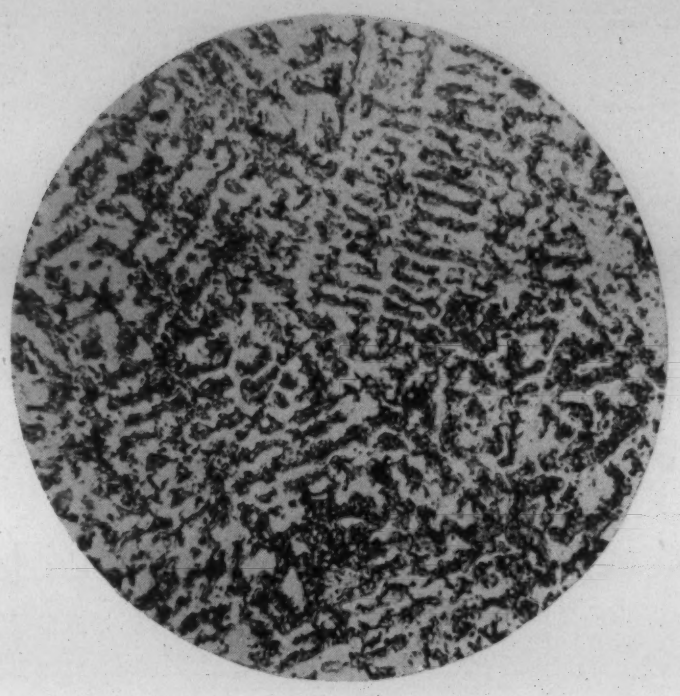
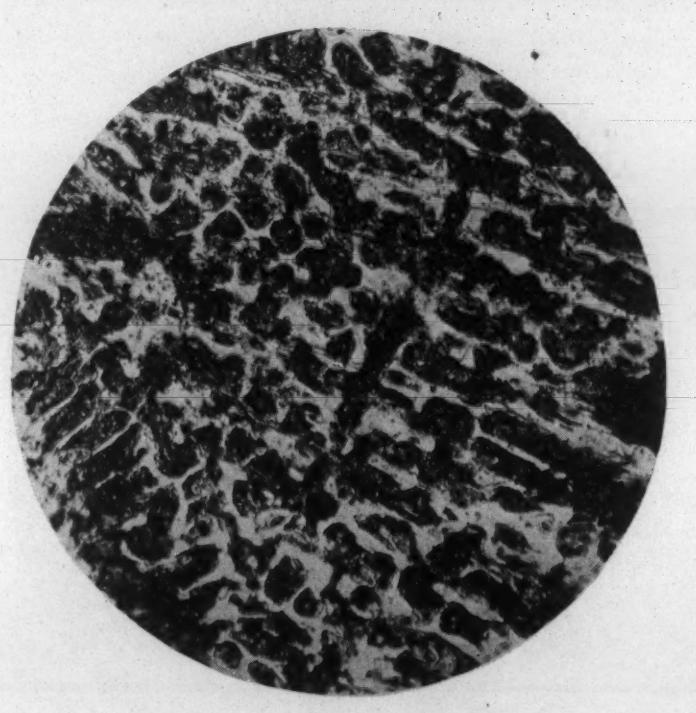


Fig. 4—Photomicrograph of Malleable Cast Iron, Showing "Temper" Carbon Nodules and Ferrite Grain Boundaries. Etched with Nital. Magnification 200×



(a)



(b)

Fig. 5(a)—White Cast Iron, Suitable for Malleabilizing. Dark Areas, Pearlite. Light Areas, Cementite. Nital Etched. Magnification 200×
Fig. 5(b)—Sample Similar to (a). Magnification 200×

Fig. 6—Photomicrograph of Gray Cast Iron. Black, Graphite, Matrix, Pearlite. Light Areas Phosphide Eutectic (Steadite). Etched with Nital. Magnification 500×

may be regarded as a steel that follows the mode of behavior of steels in general. It is true that the presence of graphite will influence the heat-treatment of gray cast irons, and, of course, will influence the strength and other mechanical and physical properties. From the classifications given for Case II and Case III above, it is seen that the range of combined carbon in cast iron covers both hypo- and hyper-eutectoid steels. Thus, we can regard a white cast iron as a very high carbon steel, and would expect it to be hard and brittle, as is the case. On annealing, however, it does not follow that pearlite and cementite will be retained. On the contrary, carbon is released from the combined form, thus malleablizing the iron.

Gray cast irons may have either a hypo- or hyper-eutectoid matrix. The strongest of the gray cast irons, are those which have a matrix of about the eutectoid composition, as would be expected. In considering gray cast iron it is convenient to regard the material as a porous steel, in which the voids are filled with graphite. From this viewpoint some of the physical properties of cast iron are readily explained. The hardness and lack of shock resistance of white cast iron have already been mentioned. In gray cast irons, the strength in tension will be low, since the graphite interrupts the continuity of the "steel" matrix, and does not adhere strongly to the steel when tension is applied. In compression, however, the discontinuity of the "steel" does not cause so great a reduction in strength, since the voids are filled with a solid material, graphite.

The Constitutional Diagrams.—The iron–cementite system is shown in Fig. 2 and the iron–graphite system in Fig. 3. These diagrams are quite widely accepted as essentially correct, at least as far as our present knowledge extends. The iron graphite system is often called the "stable system" because annealing of white or even gray cast irons tends to produce graphite. Annealing, especially if prolonged, and with a very slow cooling rate, tends to promote equilibrium conditions. Accordingly, the iron–cementite system is some times known as the "meta–stable system," since graphite, the stable phase, is not shown.

Perhaps the easiest way to consider the differences between the diagrams is to consider the slow cooling of a typical iron-carbon alloy containing, say, 3.5% carbon, designated in both Figs. 2 and 3 as M-N.

Considering first the meta-stable system: The alloy will, at temperatures in excess of 1200° C. consist of the molten solution of iron and carbon (iron carbide). Austenite will start to freeze out at the temperature indicated by 1, and continue to freeze out as the temperature falls from 1–2, with corresponding enrichment of the melt in carbon content, so that at a temperature of 1130° C. the remaining melt solidifies as the eutectic of austenite and cementite. Thus, there are two forms of austenite present, the primary austenite formed between 1200° C. and 1130° C. and the eutectic austenite. On further slow cooling, all the austenite will break down (as in the case of steels) until at temperatures below Ar_1 (approx. 700° C.) the stable phases will be ferrite and cementite. However, some of the ferrite and cementite may be present as the aggregate pearlite.

Such would be the story if the system iron–cementite, were always a stable system. It is known that the approximately pure iron-carbon alloys do not graphitize readily, and, hence, the possibility exists that no graphite would be formed on the slow cooling of a pure iron-carbon alloy. Graphite does form on the slow cooling of hypo-eutectic cast irons when silicon or another "graphitizing" element is present.

Now consider the slow cooling of the 3.5% carbon iron-carbon alloy according to the "stable system" Fig. 3. Since the liquidus line AB′ is common to both systems, austenite will start to freeze out as before at point 1 (about 1200° C.), and will continue to freeze until the temperature at 2 is reached. (Point 3 indicates the solidification point on the iron–cementite system.) The melt has been increased in

carbon content during the solidification. It will be noted that the eutectic temperature is slightly higher in this system than in the meta-stable system, and that the eutectic point is at a lower carbon percentage. At the eutectic temperature the austenite and graphite solidify from the melt.

The austenite on cooling further can deposit graphite if it contains more carbon than represented by the point S′. If it contains less, ferrite must be ejected, thus enriching the austenite in carbon until the eutectoid temperature is reached. When cooling has reached the eutectoid temperature P′S′K′, the residual austenite, whether hypo- or hyper-eutectoid in origin, breaks down, since the solubility of graphite in α-iron is very slight. Structurally, only graphite and ferrite should exist.

If the cast iron is hypereutectic, graphite as a solid phase would separate out in the area B′D′C′, Fig. 3. In high silicon pig iron excess graphite does separate out in the melt, and is known as "kish." However, alloys of this type belong to a more complex system than the simple binary system of iron and graphite, and the silicon undoubtedly influences the solubility relationships.

Since commercial cast irons do contain pearlite, as well as graphite, it cannot be said with certainty that either system can explain all observed facts. Undoubtedly the presence of the metalloids (especially silicon) produces changes which cannot be explained completely in terms of either (binary) iron–carbon system. In obtaining the thermal data from which equilibrium diagrams are plotted, slow cooling is essential in order to obtain equilibrium conditions. In the foundry the rate of cooling is one of the important variables, and the structure and properties of the castings are often changed by the use of chills or other means of controlling the rate of heat transfer from the castings. It is rather doubtful if the ordinary rates of "slow cooling" approach the rate of cooling necessary for the attainment of equilibrium.

Forms of Carbon in Cast Iron

As has been pointed out by Bolton,[6] several forms or modes of occurrence of graphite in cast iron have been generally recognized. These may be classified as: (1) A broad flake formation, with a background of finer particles, typical of hyper-eutectic cast irons. (2) The Rosette or whorl formation. (3) The dendritic striation. (4) Grouped, with dendritic lakes. (5) Temperature carbon groups. For further information reference may be made to Bolton's work. Three types of graphite formation are shown in Figs. 7, 8 and 9. The difficulties in securing representative views of gray cast iron may be mentioned. Extreme care in polishing is necessary, as gray cast iron consists of a very soft material, graphite, in a relatively hard matrix.

The combined carbon is, of course, in the form of cementite. Various forms of cementite are recognized: (1) Primary cementite formed on solidification of hyper-eutectic cast irons. (2) The cementite of the eutectic. (The eutectic is known as "ledeburite".) (3) Pro-eutectic cementite, ejected from austenite on cooling. (4) The cementite of the pearlite aggregate.

Many divergent opinions regarding the mechanism of graphitization have been advanced, but will not be considered further here.

Summary on the Relationships of Iron and Carbon in Cast Iron

1. The presence of carbon up to the eutectic percentage lowers the melting point of the alloys of iron and carbon.

2. The iron–graphite system is termed the "stable system," largely because graphite is released in cast irons upon very slow cooling. It has not been conclusively proved that graphite would be released if only iron and carbon were present in the alloy.

[6] J. W. Bolton, "Some Graphite Formations in Cast Iron." Paper before the American Foundrymens Association 1927. Abstracted, *Foundry*, Vol. 55, 1927, page 758.

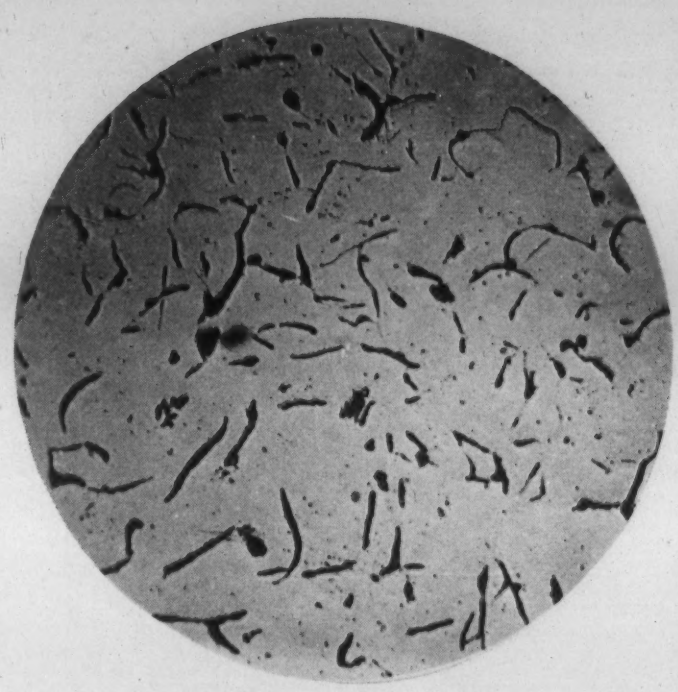


Fig. 7—Photomicrograph of High Grade Gray Cast Iron. Unetched. Magnification 100×. Same Sample as Shown in Fig. 6

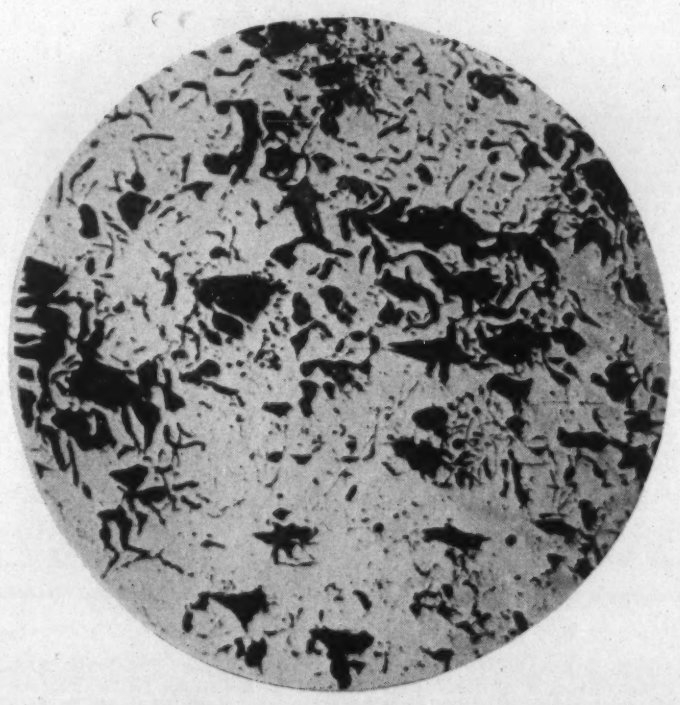


Fig. 8—Photomicrograph of Gray Cast Iron. Heavy Section. Unetched. Magnification 100×

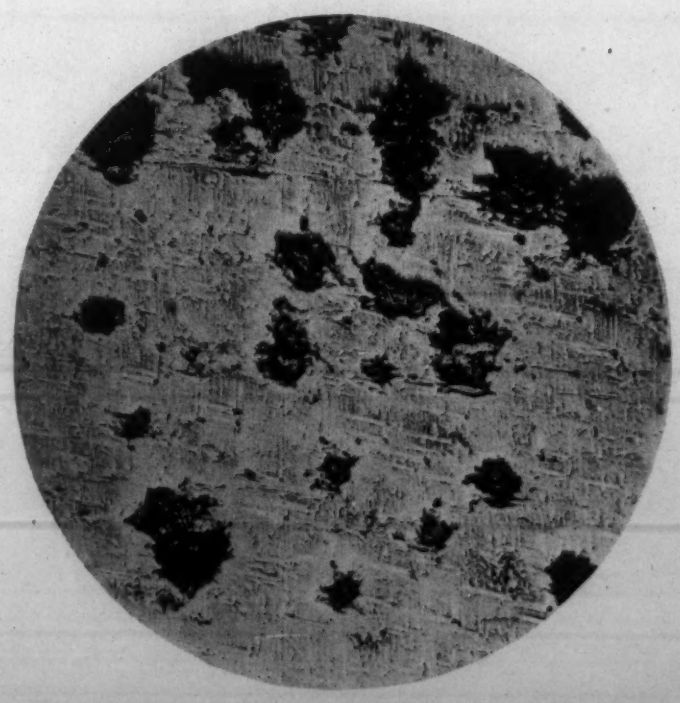


Fig. 9—Photograph of Malleable Cast Iron. Unetched. Magnification 100×

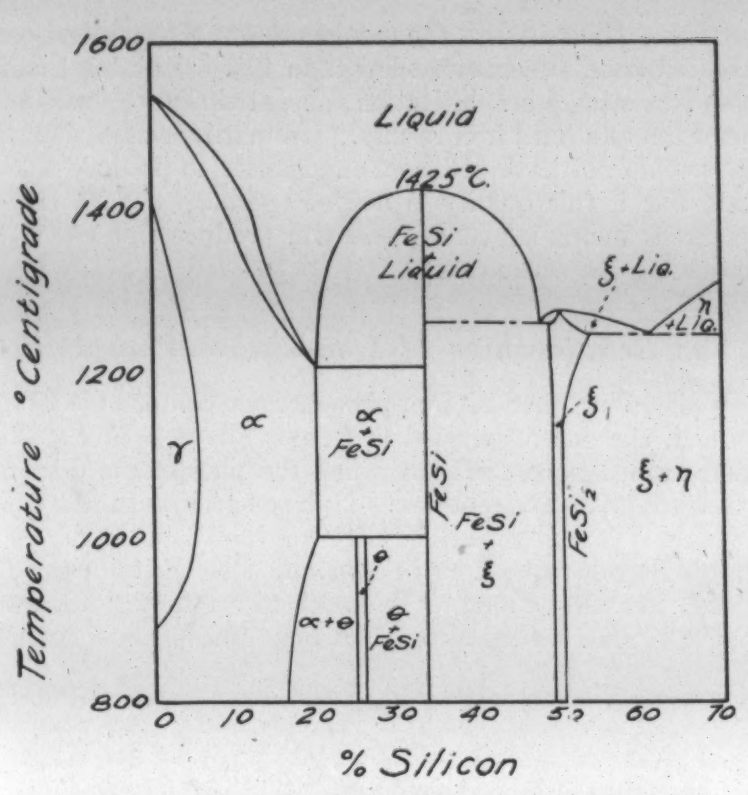


Fig. 10—Portion of the Iron-Silicon Equilibrium Diagram (From International Critical Tables)

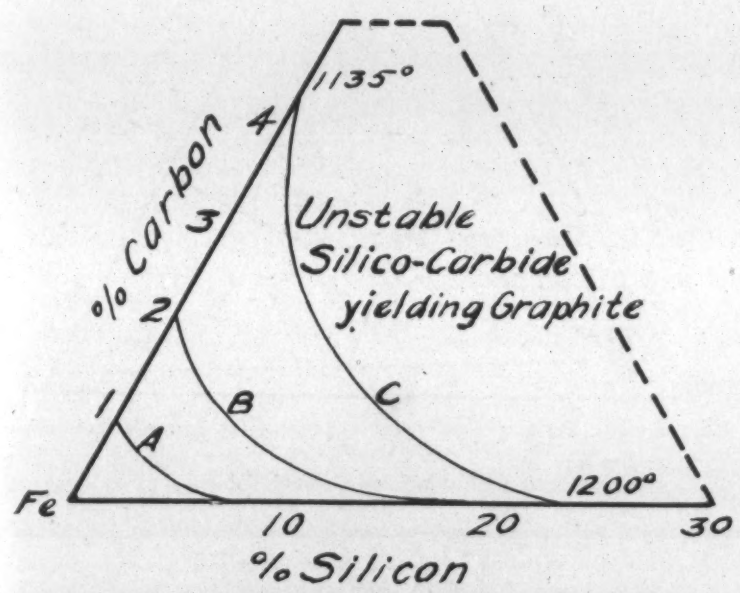


Fig. 11—The Ternary Equilibrium Diagram for Iron-Carbon-Silicon. A — Eutectoid line. B — Limit of Austenite. C — Eutectic Line (From International Critical Tables)

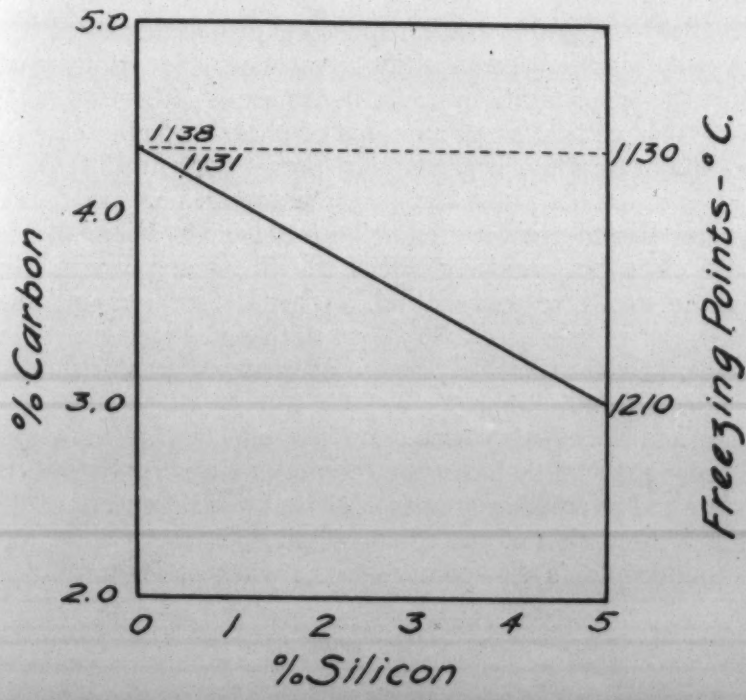


Fig. 12—Diagram Showing the Change in Eutectic Temperature and Carbon Percentage with Increasing Silicon Content in Alloys of Iron, Carbon and Silicon

3. For the usual interpretation of structures the "metastable" system, iron-cementite diagram can be used, remembering that graphite may be produced in various ways, and that for convenience in interpretation, the matrix may be regarded as a steel.

4. The rate of cooling of the casting is one of the most important variables in foundry practice.

5. The forms of graphite and cementite have been listed.

The Impurities in Cast Iron

Should silicon, manganese, phosphorus, and sulphur be regarded as impurities or as essential, if minor, constituents? Within limits, each of these elements is actually of value in the iron, under certain conditions of practice. Presumably satisfactory castings could be made from the "theoretical" cast iron, but, of course, such procedure would be out of the question for production work, as the expense would be prohibitive.

If the limits of percentage for each constituent, as found from practical experience, be exceeded, the effect on the physical properties of the cast iron may be harmful. One of the advantages in the use of cast iron as a material of construction is that the original pig iron need not be refined, and castings can be made, suitable for a large variety of uses, at a comparatively low cost. If the composition of a particular pig iron is unsuitable for use for a certain type of work, the composition can be adjusted by additions of other pig irons, scrap, or ferro-alloys. That a considerable variety of composition is needed is indicated by the analyses of mixes for certain jobs as listed in Table I. Variations in silicon content are particularly noticeable. On the whole then, we may regard the metalloids as minor alloying elements in cast iron.

Any cast iron as made in a foundry will contain the six elements: iron, carbon, silicon, manganese, phosphorus and sulphur. In general, the allowable or desired percentages of each will be greater than the limits set for steel. It would be expected that the general effects of each element on the cast iron would be same as the effects it would produce in steel, and this is true. However, the metalloids, singly or in combination are used for purposes in making cast iron for which they would not be considered in steel. For example, high phosphorous percentages may be used in cast iron for the sole purpose of increasing the fluidity of the molten iron.

Table I

Typical Variation in Compositions of Cast Iron for Various Uses*

Use	Total C	Mn	P	S	Si	Combined C
Plain "semi steel" (pressure castings)	3.37	0.82	0.18	0.090	1.47	..
Close grained castings (no chills)	3.39	0.72	0.19	0.067	1.27	..
Heavy and light section castings	3.27	0.62	0.27	0.082	1.96	..
Gear and pinions castings	3.44	1.17	0.17	0.092	1.21	..
Production castings 3/8" to 5/8" section	3.54 to 3.27	0.55 to 0.51	0.34 to 0.37	0.081 to 0.079	2.48 to 2.19	0.28 to 0.66
Machine castings, 1/2"–1" section	3.20	0.57	0.45	0.092	2.03	..
Grate bar castings	3.40	0.60	0.54	0.009	2.00	..
Jobbing castings	3.40	0.55	0.25	0.09	2.00	..

* Data abstracted from pamphlet "12 Practical Foundry Mixes" supplied by the International Nickel Co. These analyses are listed as typical of plant practice where nickel or nickel and chromium additions are not made.

The Relationships of Iron-Carbon and Silicon

When the foundryman is experiencing difficulty with shrinkage, or having other difficulties which might be traced to composition of the iron, he should first of all analyze his iron for silicon, and change the percentage if it is found incorrect for the conditions which must be met.

The logical starting point in considering the effect of silicon would be to examine the iron-silicon equilibrium diagram. A portion of this diagram is shown in Fig. 10. It is beyond the scope of this article to consider the system in detail. Reference may be made to the work of Guertler and Tamman.[7] In Fig. 10 it will be noted that the silicon, within the

[7] W. Guertler and G. Tamman," Ueber die Verbindungen des Eisens mit Silicium," *Zeitschrift für Anorganische Chemie*, Vol. 47, 1905, page 163.

limits of commercial cast irons, forms a solid solution with the iron. Two intermetallic compounds are shown, and in cast iron the FeSi is in solution with the ferrite.

In the ternary system, iron–carbon–silicon, shown in Fig. 11, increasing the percentage of silicon reduces the solubility of carbon in iron. The eutectic point is shifted from 4.3% carbon to lower values at the rate shown in Fig. 12. This curve is plotted from the data of Wüst and Petersen[8]. They also found that the melting point of the eutectic is raised as the silicon percentage is increased. The values are approximately given in Fig. 12. As Sauveur has pointed out, this diagram is useful in predicting whether the alloy will be hypo- or hyper-eutectic in composition. Above the curve hyper-eutectic is indicated, and if the intersection of the silicon composition line with the carbon line is below the curve, the cast iron will be hypo-eutectic.

The principal effect of increasing the silicon content is to increase the amount of graphitic carbon which will be present. The more silicon is present in solution, in the ferrite, the less carbon can be held in the combined form. Perhaps some of the silicon may be associated with the cementite, rendering it less stable, and thus likely to break down at the temperature of pearlite formation. See Hatfield[9].

With the higher percentages, that is above 3.5% silicon, the cast iron will become hard and brittle, this being sometimes explained as due to the formation of more of an iron silicide. When the percentage is increased to about 14%, a cast iron is obtained which is very resistant to many corrosive media, although, of course, it is too hard and brittle to machine, except by grinding, or perhaps by the use of tungsten carbide tools.

The Relationships of Iron-Carbon and Sulphur

If no manganese is present, sulphur will combine with iron to form FeS. This compound forms an alloy system with iron. One of the peculiar features of this system is that the separation of the last of the FeS from a solid solution takes place as low as 130° C. FeS promotes "red shortness" of the iron, i. e., the resistance to shock or impact is low at a red heat.

When manganese is present the compound MnS will be formed in preference to the iron sulphide. The preference of sulphur for manganese rather than iron is well established, although some authorities believe that a double sulphide of iron and manganese is formed, rather than just MnS. With manganese the sulphide occurs as "globules" or inclusions, which do not affect the strength at any temperature to anything like the extent the iron sulphide does.

Sulphur is said to exert some effect in preventing the separation of graphite, but this effect is modified by the presence of elements which cause graphitization, such as silicon.

The Relationships of Iron-Carbon and Manganese

Assuming that sufficient manganese is present to combine with sulphur, any additional manganese will alloy with carbon to form Mn_3C, which is not at least by ordinary means distinguishable from the ordinary Fe_3C cementite. If no silicon is present (a condition not met with in practice) the effect of manganese on the iron-carbon alloys is fairly well understood. It tends to increase the stability of the cementite, lowers the temperature of primary solidification and also slightly lowers the eutectic temperature. Manganese exerts an effect on the "critical ranges" (Ac and Ar points) which for the amount of manganese in ordinary cast irons would not be appreciable. When silicon is present, the effects of manganese are not so well understood. In general it is believed manganese does not reduce the tendency to graphitize conferred by silicon. The Ar_1 point is lowered, and less manganese is necessary to prevent pearlite formation, than is the case when silicon is not present. Hatfield fixes the manganese value to prevent pearlite formation at somewhat less than 4%. With low manganese percentages graphitization is assisted slightly, with high percentages a hard iron results. Ordinarily, castings for the market do not have sufficient manganese to produce a hard iron, but if this quality is needed (perhaps a hard chill is required) increasing manganese will produce this effect, by hardening the whole casting.

[8] F. Wüst and O. Petersen, "Beitrag zum Einfluss des Siliciums auf das System Eisen-Kohlenstoff," *Metallurgie*, Vol. 3, 1906, pages 811–820.
[9] W. H. Hatfield, "Cast Iron in the Light of Recent Research," 1918.

The Relationships of Iron-Carbon-Phosphorus

While a number of iron-phosphorous compounds can be formed, the one recognized in ferrous alloys is Fe_3P. This compound dissolves in iron, when the phosphorus does not exceed 1.7%. The eutectic of phosphorus with the solid solution is called "Steadite," deriving that name from one of the pioneer investigators in iron and steel metallurgy, Dr. Stead. As will be seen by reference to the ternary diagram, Fig. 13, the eutectic contains 10% phosphorus. Wüst[10]

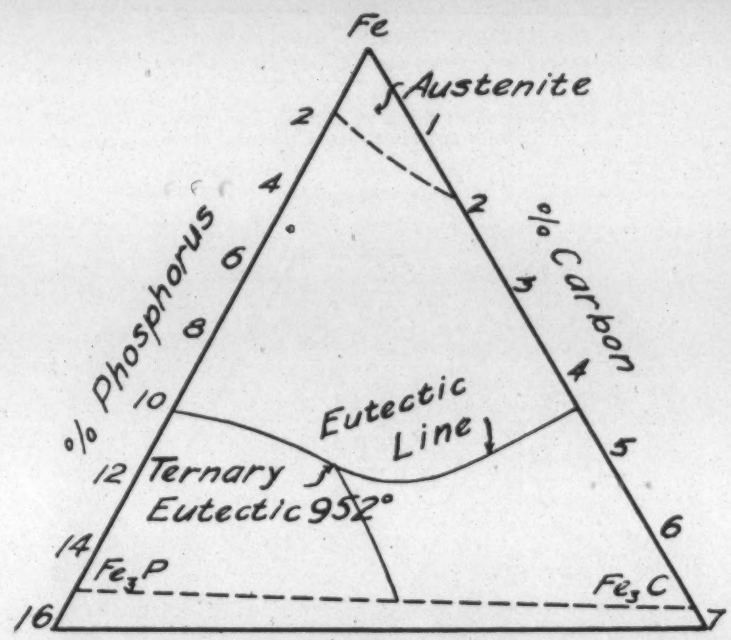


Fig. 13—The Ternary Equilibrium Diagram for Iron–Carbon and Phosphorus

(From International Critical Tables)

states that phosphorus lowers temperature of the liquidus line, about 27° C. for each percent of phosphorus. Phosphorus and carbon may be said to be in competition, that is, each lowers the solubility of the other in iron. If the carbon is high, Stead believes that all the phosphorus is concentrated in the melt as solidification occurs.

In considering the effects of phosphorus, the effect of silicon on the graphitization must again be considered. In the usual ranges of composition, phosphorus does not greatly affect the graphitization, according to some authorities, while others believe that small amounts of phosphorus increase the graphitization while large amounts prevent or retard it.

In practice the phosphorous percentage is increased in the mix in order to promote fluidity, and in moderation, this increase does not seriously affect the physical properties or promote excessive segregation. When larger amounts are added, say in excess of 0.35%, strength and shock resistance are sacrificed for the sole purpose of securing greater fluidity in pouring thin sections.

For additional information on the effects of phosphorous reference may be made to the original articles by Stead[11] or to standard reference works such as that of Sauveur.

For a discussion of the effects of phosphorus written from the foundryman's viewpoint, see the work of Bolton.[12]

[10] F. Wüst, "Beitrag zum Einfluss des Phosphors auf das System Eisen-Kohlenstoff," *Metallurgie*, Vol. 5, 1908, page 73.
[11] J. E. Stead, "Iron and Phosphorus," *Journal Iron & Steel Institute*, Vol. 58, 1900, page 60; "Iron, Carbon and Phosphorus," Vol. 91, 1915, page 140; Vol. 97, 1918, page 389.
[12] J. W. Bolton, "Phosphorus Affects the Qualities of Gray Cast Iron," *Foundry*, Vol. 54, 1926, Part I, page 378; Part II, page 423.

Snmmary of the Effects of Each of the Common Minor Constituents of Cast Iron, When All Are Present in the Iron.

Silicon.—Silicon unites with the ferrite possibly to form an intermetallic compound FeSi. Within the usual silicon percentage range of cast irons, it dissolves in the ferrite. Graphite is released in larger amounts than would be the case if no silicon were present. For this reason silicon is called a softening agent. But when the silicon content reaches 3%, the hardening and embrittling effect becomes noticeable. Silicon increases the fluidity of the cast iron and tends to decrease shrinkage and chill.

Sulphur.—Sulphur opposes the formation of graphitic carbon, hence its effect on cast iron is opposite to that of silicon. In general, sulphur tends to produce "red shortness," unless this tendency is overcome by having sufficient manganese present, and this is usually the case in cast iron. Sulphur, while usually present in cast iron, ought not to exceed 0.1% except for certain types of chilled work when up to 0.2% may be allowed.

Manganese.—The manganese content of cast iron rarely exceeds 2%, although, of course, cast irons can be made with higher percentages. Usually the range will be 0.3–0.8% of manganese. Manganese forms with carbon the compound Mn_3C. Mn_3C is associated with the cementite. Manganese also forms with sulphur the compound MnS. When the alloy solidifies, any manganese sulphide (MnS) present freezes out in minute globules, which do not greatly affect the strength of the iron. If no manganese were present, or an insufficient supply, the iron sulphide (FeS) would be formed, and its presence is injurious, as it weakens the grain boundaries at higher temperatures because of the low melting point of FeS. For this reason manganese is used to offset the bad effects of sulphur. It also acts as a hardener in higher percentages and tends to hold carbon in the combined form.

Phosphorus.—The principal effect of phosphorus is to increase the fluidity of the iron. One percent or more of phosphorus may be used on occasion, but ordinarily the percentage is much less, not over 0.3–0.4% for many purposes. Phosphorus forms a number of compounds with iron. Fe_3P is generally regarded as the principal compound present in cast iron. Phosphorus in general, tends to promote brittleness in iron-carbon alloys, but when properly controlled it can be of considerable service to the foundryman in promoting fluidity without getting too brittle castings.

Physical Effects and Defects

Certain physical changes occur during solidification of commercial cast irons, which in themselves are normal and to be expected, but which if they exceed certain values, become abnormal and the casting is defective. Reference is made to such terms as "shrinkage," "checking," "segregation" and "chilling." While these phenomena might logically be considered in an article on metallography of cast iron, discussion will be deferred until a later article.

Conclusion

The foregoing discussion of the constitution of cast iron is admittedly incomplete. Within the limits of a single article, an attempt has been made to discuss the interrelationships of the six common elements present in commercial cast irons. No attempt has been made to consider the effects of oxygen, or of small amounts of elements such as tin, or copper which might conceivably be present. Nor does this article attempt consideration of the improvements made in recent years in the structures and properties of gray cast iron by the use of special processes or alloying elements. These improvements will be considered in a later article.

Considering only the six elements commonly present, it has been shown that the constitution of cast iron is very complex, and that so many variables are present that foundrymen of necessity are forced to rely in large part on experience, judgment and knowledge of generally accepted facts as to limits of compositions, rather than being able to theoretically deduce what the composition of a cast iron should be for a certain definite purpose.

Copper in 1929

Production and consumption of copper, which assumed record-breaking proportions in the fall of 1928, continued at a high rate through 1929, according to the United States Bureau of Mines, Department of Commerce, and for the year were the highest on record. Heavy demand preceded the large increase in production and was met, in part, by stocks of refined copper, which at the end of 1928 had dwindled to the lowest on record since 1917. In 1929, production was at a sufficiently higher rate than consumption to cause stocks of refined copper to increase to more than two and one-half times those at the end of 1928 and to the highest on record since the end of 1921. The increase in imports of unmanufactured copper to a record figure and a drop in exports of 7% from the average of the five-year period 1924–1928, added to the large increase in stocks. At the end of the first quarter of 1929, stocks of refined copper having increased, consumers resumed a hand-to-mouth buying policy which had been abandoned in the fall of 1928.

Copper prices rose from a monthly average of 13.9 cents a pound in January, 1928, to 15.9 cents in December, and continued the rapid advance to a high of 23.775 cents a pound, at refinery, March 23, 1929, where it held until April 5. From April 5 to April 15 the price dropped to 17.775 cents a pound, where it remained beyond the end of the year.

The final figures on total United States copper production by primary refineries, from primary and secondary sources show that the Bureau's preliminary estimate, issued January 13, 1930, was high by 0.2%. Wider differences between final and preliminary figures on production from domestic and foreign materials of both primary and secondary origin is explainable by the fact that the final reports from refiners make possible a more exact apportionment of the production in accordance with its domestic or foreign, primary or secondary origin. This final report also shows that the preliminary estimates of producers' stocks were too low by 15%.

Phos-Copper Welding Alloys

The Westinghouse Electric and Manufacturing Company announces its Phos-Copper Welding Alloys. Years of research have produced a product of absolute uniformity and guaranteed analysis which makes neat, strong and dependable copper and copper base alloy joints and connects without requiring the use of a flux. Phos-Copper Alloys are manufactured and sold under Westinghouse patents.

Phos-Copper marketed in rod and strip form is composed essentially of copper and from 5–10% phosphorus, the rod form containing slightly more phosphorus than the strip form. The fluidity of the material is directly proportional to the phosphorous content. The higher the degree of fluidity, the better will be the alloying, penetrating and cementing properties at a comparatively low welding or fusing temperature.

Phos-Copper begins to melt at approximately 700° C. (1292° F.) and becomes extremely fluid at 750° C. (1382° F.) for the rod and 800° C. (1472° F.) for the strip form.

The presence of the phosphorus prevents the oxidation of both the copper and the surfaces being joined, thereby acting as a flux and producing a sound and dependable joint. At the same time, the phosphorus lowers the melting point and gives the alloy the characteristic of flowing freely when fused. The phosphorus partially burns out, leaving a uniform joint or connection.

The alloy in rod form is comparatively brittle at ambient temperatures, but a chemical change takes place during the welding process, making the deposit in the joint strong, tough and ductile. The strip form alloy is soft and sufficiently ductile to be slit to any desired width or length, and will form punchings down to a radius of 0.064 inch. The latter is often desirable wherever pipe and coil connections can be made by using Phos-Copper punchings of the proper diameter.

The tensile strength of the deposit or joint varies from 18,000 – 30,000 lbs./in.^{2}, and is greater than that of copper, but the ductility is less than that of copper.

Preferred Orientation in Silver Foil Produced by Cold Rolling*

By Cleveland B. Hollabaugh

Introduction

Statements can be found in the literature to the effect that the cold rolling of metals having a face centered cubic crystal structure causes one definite orientation. This preferred orientation is said to be independent of the rolling technique, and is given[1] as the position in which the (0 1 1) plane of the crystal is parallel to the rolling plane and a (1 1 2) plane parallel to the direction of rolling.

This broad conclusion is questionable since in the case of one of the face centered cubic metals, aluminum, it has been shown[1] that a second orientation is possible, and that it is to be doubted that aluminum ever assumes the above specified orientation. Likewise, in the case of zinc, a metal having a hexagonal lattice, some unpublished research[2] has shown two possible orientations. This evidence supports the idea that the orientation assumed by the grains in a metal depends upon the type of deformation to which it has been subjected. This idea contradicts the general conclusion regarding face centered cubic metals, but not the experimental data of Mark and Weissenberg[3,4], on which it is based. These data were obtained by the interpretations of patterns made by the monochromatic pinhole method, of single samples of each metal.

On the basis that the orientation assumed in a metal is dependent on the rolling technique employed, it was thought worth while to study the effect of cold rolling on the crystal arrangement in a face centered cubic metal. This study has been carried out by using a method[2] by which the crystal orientation may be studied in sheets too thick for study by the transmission method. The data secured show, not a single orientation, but a range of orientations which includes the position described by Mark and Weissenberg[3] and by Glocker.[5]

Survey of Previous Work

Vegard[6] showed silver to have a face centered cubic crystal lattice and measured its lattice parameter, as later did McKeehan.[7] Precision measurements by Davey[8] have shown the lattice parameter of silver to depend upon its purity. For "fine" silver (99.9% pure) he gives 4.058 ± 0.004 A. U., while for silver of atomic weight purity (99.999% pure) he gives 4.079 ± 0.004 A. U.

There have been two papers published on the effect of cold rolling on the crystal orientation in silver. The earlier of these, by Mark and Weissenberg,[4] gave the preferred orientation described above. The other one, by Glocker,[5] confirmed this orientation and reported a research on the effect of annealing on the crystal structure of the foil. He showed that the first transition occurring on annealing is a change from the original oriented condition to an arrangement with the (1 1 2) plane parallel to the plane of rolling at temperatures from 200–212° C. This condition he shows to remain unchanged for all temperatures below 750° C. Above this temperature a transition occurs which gradually results in a completely random arrangement of the grains in the metal.

* A thesis submitted in partial satisfaction of the requirements for the degree of Master of Science.

Contribution from the Physico-Chemical Laboratories, Department of Chemistry, School of Chemistry and Physics, The Pennsylvania State College, State College, Penna.

Experimental

Apparatus.—Two types of apparatus were used for the patterns taken during this research. One was specially built for taking X-ray patterns by the pinhole method. It consisted of a pinhole system in the side of a lead box enclosing a rigidly supported and properly aligned X-ray tube, and a suitable device for holding an X-ray film in the proper position opposite the pinholes. The other one was a diffraction apparatus of the type[9] built by the General Electric Company. The source of the radiation in each of the sets was a water-cooled Coolidge tube having a molybdenum target. It was operated at 30 kilovolts giving the radiation of the K series for molybdenum.

To aid in the interpretation of the reflection patterns, an adjustable mounting was built, for holding a crystal lattice model rigidly in any desired position.

Sample.—The sample of silver used was "fine" bar silver. Since its purity was not known, it was highly desirable to know what kind of an X-ray diffraction pattern it would produce. A powder diffraction pattern of the silver was made using a technique,[10] which is adapted for securing patterns for precision measurements. This pattern was measured in the usual way and the results obtained in terms of the interplanar spacing by the precision method described by Davey.[10] These results checked exactly with those given[8] for silver 99.9% pure.

Annealing Study.—Since the available sample of silver had an unknown rolling treatment and since it was too thick for convenient use, it was desirable to roll it to a thinner cross section and then remove all traces of orientation by the proper annealing treatment. The purpose of this study was to determine a proper annealing treatment.

Taking the X-ray study by Glocker[5] as a basis, it was expected that it would be necessary to heat the metal to a temperature above 750° C. and keep it there for a long enough time for the grains to rearrange themselves into a completely chaotic condition. A study was made of the effect of time and temperature of annealing, using both the pinhole transmission and the reflection type of diffraction pattern. The latter of these types proved of more value, because it was more sensitive to slight traces of orientation.

Corresponding to the two types of patterns made, two samples were used. The first of these was a foil 0.0183 cm. thick, which had been rolled from a bar of 0.318 cm. thickness. This sample was used with the transmission method. A pattern was made of it before annealing and then portions of it were given various annealing treatments in a reducing atmosphere (hydrogen) and diffraction patterns made as listed in Table I. These patterns indicated that at 800° C.

Table I Patterns Made for the Study of Annealing

No.	Type of Pinhole Pattern	Thickness of Sample (cm.)	Time of annealing (Minutes)	Temp. (° C.)	Orientation Comment
4a	Transmission	0.0183	No annealing		Well shown
5a	Transmission	0.0183	30	850	Very slight
6a	Transmission	0.0173	60	850	Very slight
7a	Transmission	0.0183	3	850	Very slight
8a	Transmission	0.0183	3	800	Slight
9a	Transmission	0.0183	30	800	Slight
10a	Transmission	0.0183	60	800	Slight
4	Reflection (across rolling)	0.1448	No annealing		Well shown
5	Reflection (along rolling)	0.1448	No annealing		None
6	Reflection (along rolling)	0.1448	30	800	None
7	Reflection (across rolling)	0.1448	30	800	Slight
8	Reflection (across rolling)	0.1448	30	800	Same sample as for (7) still shown
9	Reflection (across rolling)	0.1448	30	900	Absent

and at 850° C., the time of annealing (within the limits used) has no noticeable influence on the condition of orientation, and that the annealing is more nearly complete at 850° C. than at 800° C., but a temperature of 900° C. is required to produce a completely random arrangement in less than one half hour of annealing. The standard annealing technique adopted for silver was thirty minutes heating at 900° C. in an atmosphere of hydrogen.

Rolling Series.—The original sample, 0.318 cm. thick, was cold rolled to a thickness of 0.1448 cm. and annealed in hydrogen for thirty minutes at 900° C. This sample was then given eight successive passes through a set of rolls of the usual design, having rolls $2^1/_2$ inches in diameter. A piece of metal suitable for a reflection sample was cut off and saved after each pass, care being used to label the sample showing just how it went through the rolls. Each of these samples was trimmed so that its edges were exactly parallel and perpendicular to the direction of rolling. The thickness of each sample of the rolling series is given in Table II.

Table II Samples of Rolling Series for Orientation Study

Sample No.	Total Number of Passes Through Rolls	Thickness
1	0 (annealed)	0.1448 cm.
2	1	0.1341 cm.
3	2	0.1125 cm.
4	3	0.1110 cm.
5	4	0.1003 cm.
6	5	0.0698 cm.
7	6	0.0437 cm.
8	7	0.0239 cm.
9	8	0.0135 cm.

Technique Used for Securing Diffraction Patterns from the Surface of the Foil.—The method used to secure the patterns for the measurement of orientation was the pinhole reflection method. A heterogeneous radiation consisting chiefly of the characteristic radiation of the K series for molybdenum was defined by a system of fine pinholes. This beam was allowed to impinge on a sheet of silver which was placed at an angle of approximately 10° to it and in a position such that the upper edge was nearly horizontal. It will be shown later that the angle between the edge and the horizontal can be found by an inspection of the photographic film. To record the diffraction pattern from the sample a 5 × 7 Eastman Duplitized film enclosed in a light proof holder was mounted vertically at a distance of 5 cm. and in such a position that the undeviated X-ray beam would have struck about an inch from the bottom and half-way between the two sides. This set-up is illustrated in Fig. 1.

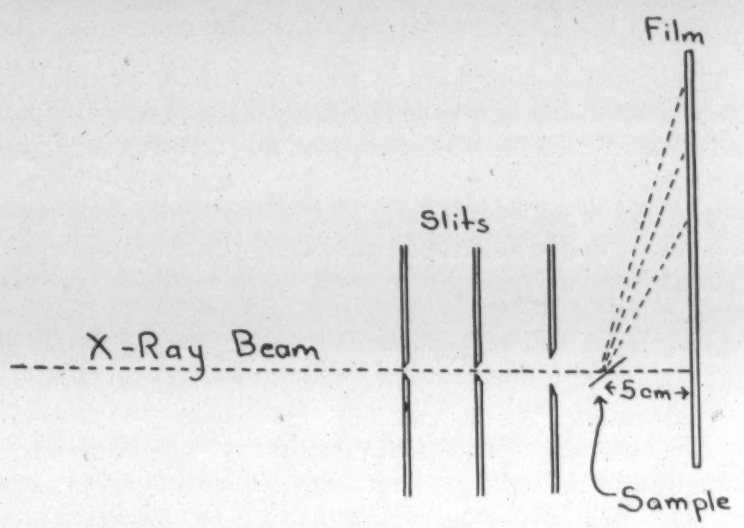


Fig. 1

The film in this position was exposed to the diffracted rays long enough to secure a satisfactory pattern (usually 70 hours). The sample was then removed from the path of the beam, the film being left in place, and the beam allowed to strike the film for ten seconds to produce a center spot. Unfiltered rays were used in almost all cases to reduce the time of exposure to a minimum. A diffraction pattern taken in this way is shown in Fig. 2.

Patterns Made.—Two diffraction patterns were made of each sample. One of the two patterns was taken with the

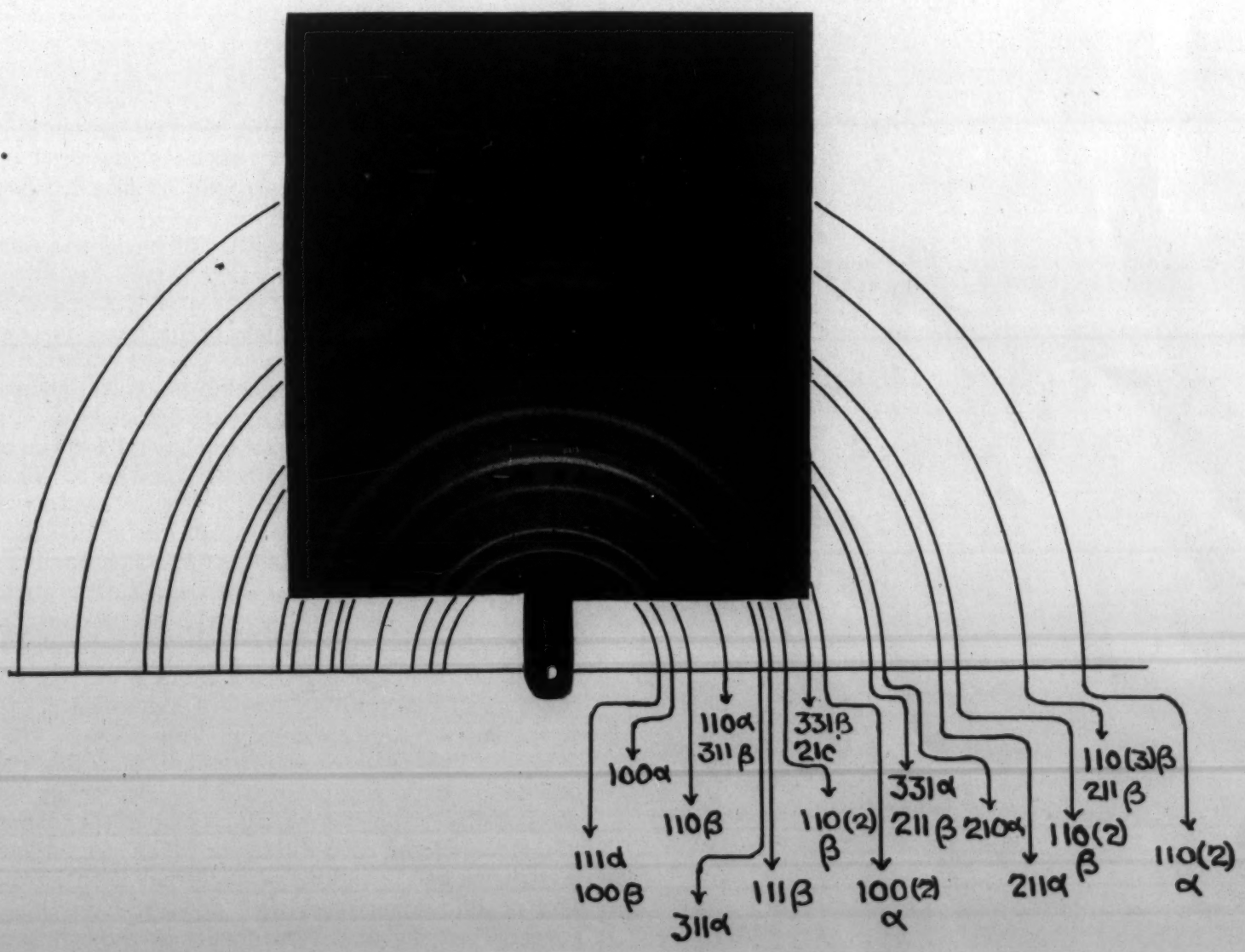


Fig. 2

sample so placed that a plane perpendicular to the sheet of metal included the incident beam and the direction of rolling, or in other words, so that the incident beam impinged on the specimen along the direction of rolling. The other one was taken in such a manner that the incident beam impinged on the specimen across the direction of rolling. Two such patterns from each sample furnished sufficient information to determine the orientations of grains in the surface of the sheet of metal.

Interpretation of Patterns

The crystal orientations in the rolled silver samples were determined using a method described by Davey, Nitchie and Fuller.[2] The first step in this method was to identify the atomic planes from which the X-rays were diffracted to give each diffraction ring of the pattern. The second step, then, was to determine the range of orientations of the crystals responsible for the regions of increased intensity on the rings.

Identifying the Rings.—This process was greatly complicated by the fact that unfiltered radiation was used in making the patterns. The first step in identifying the lines was to calculate all of the theoretically possible lines on the assumption that only the characteristic lines of the K series for molybdenum were diffracted with an intensity great enough to affect the film. Referring to Fig. 1, it can be seen that if 2Θ be the angle of the atomic plane to the primary X-ray beam, then it will be diffracted through an angle 2Θ. The distance from sample to film on the experimental set-up was approximately 5 cm., hence the distance r from the center spot to a given diffraction ring is,

$$r = 5 \tan 2\Theta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where the angle Θ is the angle between the primary beam and the atomic planes responsible for the ring. It is possible to find r by combining equation (1) with the Bragg equation,

$$N\lambda = 2d \sin \Theta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

in which λ is the wave length of the X-rays used and d is the spacing of the diffraction planes in the crystal.

The radii of the diffraction rings so calculated are listed in Table III. For these calculations the wave lengths of the K series of molybdenum used were those given by Duane,[11]

i. e., $\alpha_2 = 0.7121$, $\alpha_1 = 0.7078$, $\beta = 0.6311$ and $\gamma = 0.6197$,

Table III Calculated Radii of Diffraction Rings on Reflection Films for K Series of X-Rays

Plane	d	α_2 0.7121	α_1 0.7078	β 0.6311	γ 0.6197
111	2.35	1.57	1.56	1.38	1.36
100	2.03	1.84	1.83	1.61	1.58
110	1.436	2.74	2.72	2.37	2.32
311	1.225	3.35	3.32	2.87	2.80
111 (2)	1.173	3.54	3.52	3.03	2.96
100 (2)	1.013	4.37	4.36	3.67	3.58
331	0.930	5.00	4.95	4.15	4.04
210	0.980	5.21	5.16	4.30	4.18
211	0.828	6.17	6.09	4.97	4.82
511, 111 (3)	0.781	6.94	6.85	5.49	5.31
110 (2)	0.721	8.38	8.25	6.38	6.15
531	0.689	9.48	9.32	7.00	6.74
110 (3), 221	0.680	9.87	9.69	7.22	6.94
310	0.645	11.78	11.54	8.18	7.83
533	0.622	13.61	13.28	9.01	8.57

while the d used for each interplanar distance was that measured directly.[8] In this way all the possibilities for lines on any diffraction pattern for silver were included.

As an illustration, the calculation of the radius of the diffraction ring produced by α_2 from the (1 1 1) plane follows:

$$n\lambda = 2d \operatorname{Sin} \Theta \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$0.7121 = 2 \times 2.55 \operatorname{Sin} \Theta$$

$$\operatorname{Sin} \Theta = \frac{0.7121}{4.70} = 0.1515 \text{ and } \Theta = 8^\circ\ 43'$$

$$5 \tan 2\Theta = 5 \times 0.3140 = 1.57 \text{ cm. radius}$$

The atomic planes which gave rise to the diffraction rings were identified by direct comparison with rings drawn from the data on Table III. This comparison was made on a positive print rather than on the original negative of the diffraction pattern and the names of the planes were written next to their respective diffraction rings as shown in Fig. 2. These identifications were then checked by a consideration of the relative intensities of the α_2, α_1, β and γ wave lengths in the primary beam and the atomic population of the given plane.

A further check on the identification was obtained by taking a reflection pattern using a monochromatic beam and comparing it with the positive print of a similar pattern made with the unfiltered beam. Every line identified on the unfiltered pattern as being produced by the α doublet appeared on the monochromatic pattern and the monochromatic pattern showed no other lines.

Identifying the Spots.—The diffraction patterns made with the X-rays impinging along the direction of rolling consisted of rings of uniform intensity. This indicated that no orientation was preferred in that direction. Such a pattern is shown in Fig. 2. On the other hand, the patterns made by the rays diffracted across the direction of rolling gave certain of the diffraction rings showing some portions of the arcs more intense than others. This showed that with respect to that direction there were certain positions preferred by the crystals. Such a pattern is shown in Fig. 3.

The following procedure for interpreting the pattern of Fig. 3 will illustrate the method[2] for determining the preferred orientation. The positive print was pasted to a large sheet of paper and the rings of the pattern were labeled first with their Miller indices and then with a serial number for reference. The spots on the rings were likewise numbered, the spots from any wave length other than the σ doublet being ignored. Lines were drawn from the center spot O, past the edge of each spot and extended beyond the print. The paper with its attached positive print was then mounted vertically and a model of a face-centered cube, made accurately to scale, was then placed at a convenient height in front of the pattern. A string was then stretched from a horizontal support to the model in such a way that it was exactly normal to the print at O. This string represented the primary beam of the experimental set-up. The model was then turned to such a position that the (1 0 0) plane could have reflected to the center of spot 2, ring 2. This fixed the median location of the plane, but not its orientation about an axis normal to itself. The model was then rotated about an axis normal to the (1 0 0) plane, until the (1 1 1) plane was in a position to give spot 1, ring 1. This fixed the approximate mean of one of the possible orientations. The exact orientation range was found by placing the model in such a position that a normal to the (1 0 0) plane made the same angle to the horizontal as that made by O H in Fig. 3. At the same time, the normal to the (1 1 1) plane made the same angle as that made by the O D in Fig. 3. This angular position was then measured. The crystal model was rotated until the normal to the (1 0 0) plane made the same angle as that made by the O K in Fig. 3. This angular position was then measured. This position and the first one measured defined the extremes of the preferred orientation. All of the remaining spots on the positive print were then investigated to determine which could be accounted for on the basis of this orientation which was called A. The spots so accounted for are indicated in Table IV.

It was likewise necessary to show that this position of orientation could give no spots not shown on the film. This was done by trial and error, i. e., trying all the planes possible in a face-centered cube within the limits of interplanar spacings shown on the diffraction pattern. Such a trial showed that no diffraction spots were possible except those which appeared on the film. Orientation A did not account for all the spots, so that a second orientation had to be found

by repeating the above procedure, using the spots not accounted for by A. This was called orientation B.

In referring the position of the crystal model back to the position of the crystal in the foil, the assumption was made that the foil was placed horizontal. The photographic film was always mounted (see Fig. 1) so that its upper edge was horizontal. It was, therefore, possible to correct the interpretation for orientations for errors due to deviations from a horizontal setting of the foil by measuring the angle between the X-ray shadow of the specimen and a line parallel to the edge of the film. The orientation as calculated was then corrected for this deviation by adding it to one orientation and subtracting it from the other. The net result was the same as if in the original calculation of orientation, instead of the edge of the film being placed horizontal, the shadow of the specimen had been placed horizontal.

Interpretation of the Data

Orientation A may be visualized in terms of the foil which gave the diffraction pattern of Fig. 3 as follows: Consider for purposes of reference a face-centered cube with its cube face parallel to the surface of the foil and with one of its face diagonals parallel to the direction of rolling. Using the other face diagonal as an axis, rotate the cube until the first face diagonal is not less than 11° nor more than 44° to the direction of rolling. The direction of rotation is such as to raise that end of the face diagonal which points to the end of the foil entering the rolls first. Now allow the cube to be rotated at random about the direction of rolling as an axis. At any point in this random rotation the cube will be within the limits of the preferred orientation of the rolled silver provided only that the face diagonal makes an angle of 11-44° to the direction of rolling. This might be expressed as a "mean preferred orientation" of 27° with a degree of preferment of ± 16°.

Orientation B may be similarly visualized, the difference being only that the limits of rotation of the first face diagonal are 12° and 40° and that the direction of this rotation is opposite to that of A. The differences between the angular limits of A and B are within the experimental error.

Table V gives the limits of orientation found for all the foils listed in Table II. It will be noted that the corrected orientations show no definite effect of either percentage reduction per pass or absolute reduction per pass. With the exception of the first and possibly the second pass through the rolls, the values are close enough to a mean to suggest

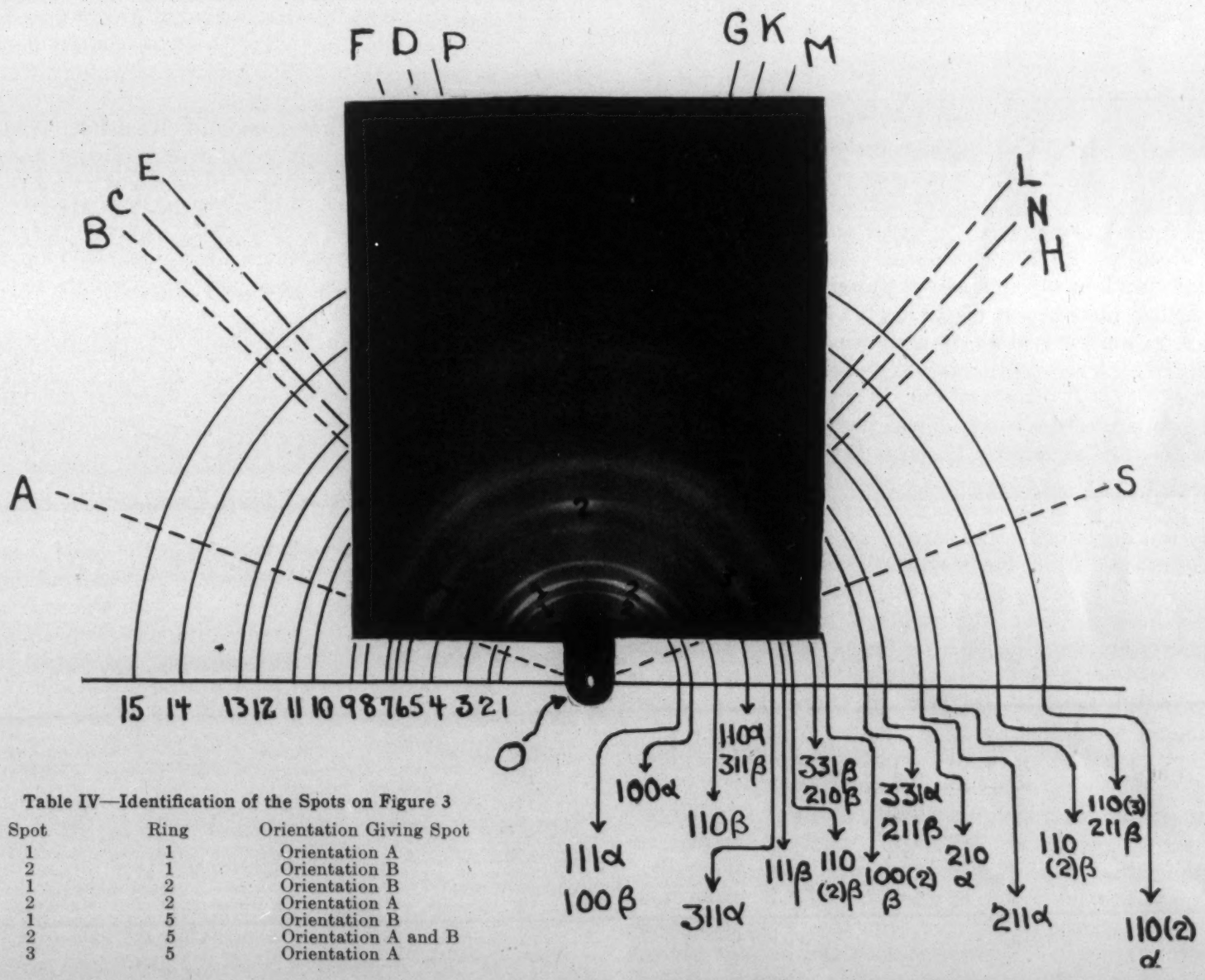


Fig. 3

Table IV—Identification of the Spots on Figure 3

Spot	Ring	Orientation Giving Spot
1	1	Orientation A
2	1	Orientation B
1	2	Orientation B
2	2	Orientation A
1	5	Orientation B
2	5	Orientation A and B
3	5	Orientation A

Table V—Orientations Measured in Silver Samples Listed in Table II*

Sample No. See Table II	Orientation A	Orientation B	Angle of Foil to the Horizontal	Corrected Orientation A	Corrected Orientation B
2	+13° to +38°	− 7° to −29°	0°	+13° to +38°	− 7° to −29°
3	+13° to +44°	−14° to −44°	+2°	+11° to +42°	−16° to −46°
4	+10° to +49°	−14° to −46°	0°	+10° to +44°	−14° to −46°
5	+13° to +42°	−14° to −40°	+2°	+11° to +40°	−16° to −42°
6	+13° to +46°	−10° to −38°	+2°	+11° to +44°	−12° to −40°
7	+ 7° to +46°	− 8° to −44°	0°	+ 7° to +46°	− 8° to −44°
8	+13° to +42°	−14° to −40°	0°	+13° to +42°	−14° to −40°
9	+16° to +50°	− 6° to −30°	−5°	+11° to +45°	−11° to −35°

Average Corrected Orientation A—+10° to +42°
Average Corrected Orientation B—−12° to −40°
Mean Position for Orientation A, +26°
Mean Position for Orientation B, −26°

*Each orientation is stated in terms of the position of a face diagonal of the cube.

that the variations between them may be due to slight differences in technique and to uncertainties in locating the ends of the strong spots on the photographic film.

The average of the mean orientations of A is, within the precision of the data, the same as the average of the mean orientations of B. This means that the grains tend to assume two orientations which are symmetrical with respect to the surface of the foils. It will be noticed that each of the preferred orientations was such that one (1 1 0) plane was perpendicular to the surface of the foil and was parallel to the direction of rolling. This is shown for orientation A in Fig. 4. There are then for each orientation two important

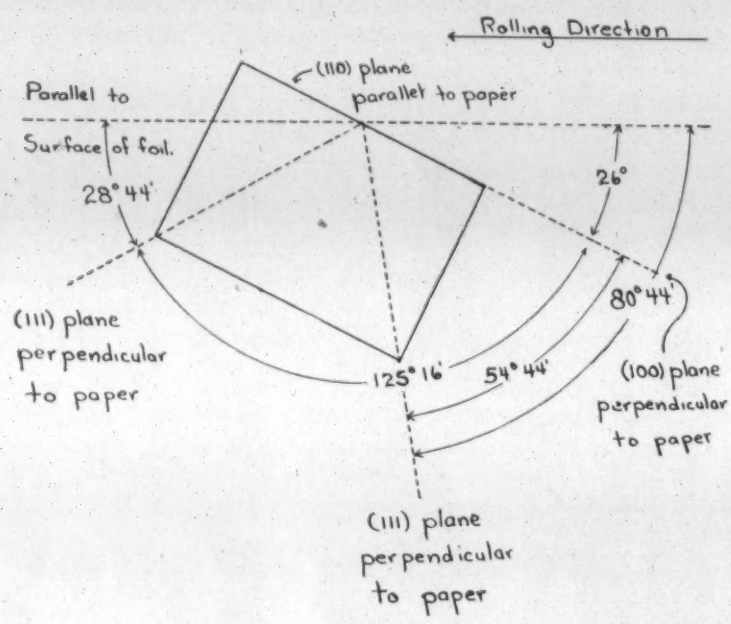


Fig. 4

sets of (1 1 1) planes in each crystal. These cut the surface of the foil in a line which is at right angles to the rolling direction. The intersection of these (1 1 1) planes with the (1 1 0) planes mentioned above is shown by the dotted lines on the figure. A simple calculation gives an angle of 54° 44′ between the (1 0 0) plane and one of the (1 1 1) planes and an angle of 125° 16′ between it and the other one. With a mean of 26° for the angle of the (1 0 0) plane to the surface of the foil, one (1 1 1) plane will make an angle of (26° + 54° 44′) = 80° 44′ to the surface of the foil, while the other one gives an angle of 28° 44′ = 180° − (26° + 125° 16′). Since the other orientation is symmetrical, the angles of its (1 1 1) planes will be the same as with this one.

A critical comparison of the results obtained by Mark and Weissenberg[4] and by Glocker[5] for the preferred orientation in silver foil demonstrates that their preferred position is included in the range of preferred positions demonstrated in the present work.

Glocker[5] in summarizing his work states, "Bei Silberblechen hohen Walzgrades wird die von Mark und Weissenberg angegebene Walzstruktur (Walzrichtung (1 1 2), Walzebene eine (0 1 1)- Ebene) bestätigt." Here he merely reaffirms the earlier conclusion of Mark and Weissenberg that the preferred position is one in which the (1 1 2) plane is in the rolling direction and the (0 1 1) in the plane of rolling. This interpretation is in agreement with that usually given.[1]

The wording of Glocker's statement is rather confusing, until it is realized that by "Walzebene" he does not mean the rolling plane as usually referred to in English, i. e., the surface of the rolled foil, but one perpendicular to it and at right angles to the direction of rolling. That this is true becomes evident on reading Glocker's article.

For convenience in comparing Glocker's preferred position with that obtained in this research, the position which Glocker gives will be described by our method. He found two symmetrical orientations corresponding to our A and B. To visualize his orientation A, consider for reference a face-centered cube with its cube face parallel to the surface of the foil and with one of its face diagonals parallel to the direction of rolling. Using the other face diagonal as an axis, rotate the cube until the first face diagonal is at an angle of 35° to the direction of rolling. This places the (1 1 2) plane in the rolling plane parallel to the surface of the foil. If the direction of rotation for orientation A is such as to raise the end of the diagonal which points to the end of the foil entering the rolls first, then orientation B is a symmetrical position in which the rotation is in the opposite direction. It is at once evident that these symmetrical positions are included in the orientation range found here, but they do not coincide with the mean preferred position of 26° found here.

Then the essential difference between the results reported here and those obtained by Mark and Weissenberg and by Glocker lies (1) in the fact that here the orientation range has been determined, while the previous workers reported a single position as being the preferred one; and (2) in the fact that the single position reported in the literature is not the mean position of that range of positions found in the present work.

Summary of Results

The mechanical working of silver by rolling produces two preferred orientations of crystals. These preferred orientations and the "degree of preferment" of each has been found. These preferred orientations are not affected by either the percent reduction per pass, nor the absolute reduction per pass through the rolls.

These results have been compared with the results published by other workers. It is found that the published work gives a single preferred position which is included in the "degree of preferment" described in the present work, but which is not the mean preferred position.

Acknowledgment

The writer wishes to acknowledge the helpful suggestions and criticism of Dr. W. P. Davey, who suggested the problem and directed the work on it.

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Methods of Testing Welds

Survey of Methods Available for Determining Ability of Welders and Quality of Welded Products

By George B. Moynahan*

Procedure Control

Adoption of procedure control as a method of insuring welded products of uniformly high quality has served to emphasize the practical importance of testing welds. Only a few years ago the testing of welds was confined almost entirely to research laboratories. To-day it has assumed practical significance in almost every field where welding is used.

Experience with procedure control proved that by means of suitably devised qualification tests it was possible to obtain an accurate evaluation of a welder's ability; that periodic repetition of such tests would make certain that the welder's ability remained at the high standard desired; and that careful inspection and tests of the finished products would further insure successful results.

During recent years much serious study has been devoted to methods of testing welds. Many methods have been developed and applied in practice. The ideal of a simple, non-destructive test that will quickly and easily indicate the exact quality of every point in a weld in a finished product has not been attained, but investigations are constantly in progress aiming toward such a method.

It is of interest to review the various testing methods that are in general use at the present time.

Testing Welds for Strength

Tensile Test.—For determining the strength of the welds that a welder is able to produce, the accepted practice is to have him prepare test specimens from which standard tensile test coupons can be cut and pulled.

For work on steel plate, for example, test specimens are made by welding together two pieces of steel plate, each 9 × 12″. The plate should be at least as thick as the material to be used in actual work. One 12″ edge of each plate should be beveled for single or double vee, according to type used. Type of welding rod and amount of reinforcement should also be specified.

It is also customary to have the welding foreman or inspector watch the operator while the test weld is being made, in order to observe details of the welder's technique. For production work, the rate of welding is also an important part of the qualification test and it is customary to specify that the test be completed within a certain time.

Unless a tensile machine is available, completed test pieces should be sent to an approved laboratory for test. From the center of each specimen, four standard A. S. T. M. coupons are cut. After removing the weld reinforcement, the coupons are pulled in a tensile testing machine. Where High Test welding rod has been used in making the welds in firebox quality plate, the coupons should show an average ultimate strength of not less than 52,000 lb./in.²

The qualification test may also contain a specification requiring a minimum of 50,000 lb./in.² for any coupons that may fracture in the weld and a minimum of 48,000 lb./in.² for coupons that break in the plate. If any fractures occur through the weld, they must show freedom from appreciable defects.

Test plates are usually welded in a horizontal position, but if the work demands vertical or over-head welding, operators should be required to submit additional test specimens welded in these positions.

Tensile tests are also required in qualifying welders for work on pipe lines or high pressure piping systems. The usual procedure is to have the operator weld together two short pieces of pipe (about 9″ in length), the pipe size and manner of welding being the same as used on the job. The pipe specimen should not be less than 6″ in diam., however. Thus, welders may be qualified for making rotating welds, position welds or, for piping work, welds of the type used in vertical risers. The method of beveling the pipe ends and the amount of reinforcement should be specified. During the test, the welding inspector or supervisor should observe the technique followed by the applicant and satisfy himself that the time required falls within the limits set for production work.

Upon completion of the weld and after the piece has cooled to room temperature, standard tensile test coupons should be cut at specified points, such as top, bottom and each side, with the weld in the center of each coupon. After removing the reinforcement by grinding or machining, the coupons are pulled in a tensile machine. See Fig. 1.

Bend Test for Strength.—Where it is not feasible to have tensile tests made, the method of bending welded specimens in a vise may be used to give an indication of the strength and character of workmanship. Test pieces should be welded as outlined above using plate or pipe, as the case may be.

Strips at least $1^1/_2$″ wide and not less than 8″ long should be cut from the test piece.

Without removing reinforcement, the strips should be tested by gripping the specimen in a vise with the weld flush with the jaws, Fig. 2, and sledging against the side from which the weld was made until the piece is bent through 90°.

* Linde Air Products Co.

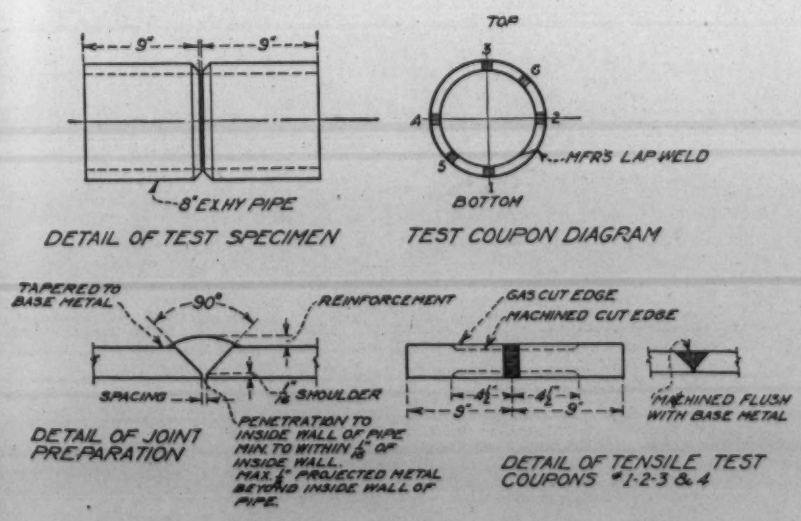


Fig. 1—Tensile and Bend Test Specimen for Pipe Welding

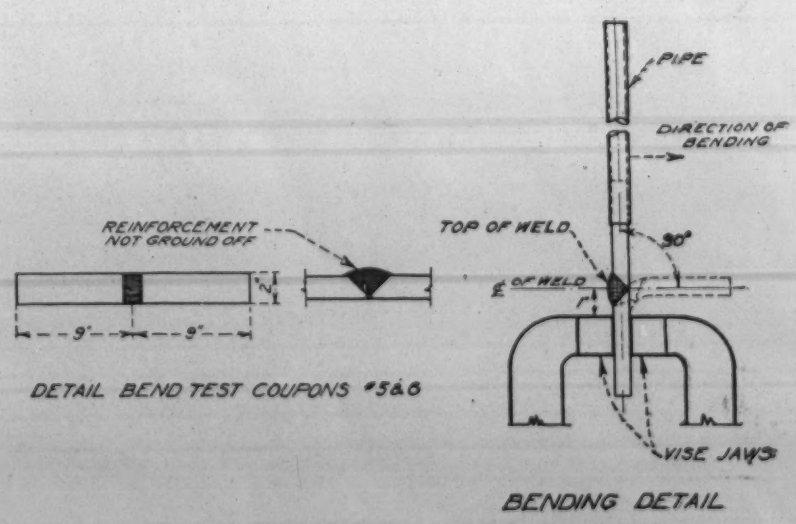


Fig. 2—Method of Bending Pipe Specimens

A satisfactory test specimen should not fracture under this test.

The specimen should then be reversed and hammered from the opposite side until fracture occurs. The fracture of a satisfactory specimen should occur either outside the weld, or if in it, should show the following characteristics: full penetration, thorough fusion, no gas pockets, cold shuts or other defects.

Fig. 2 gives directions for bending test pieces cut from a welded pipe specimen prepared according to Fig. 1.

Testing Welds for Soundness

Pressure Test.—For products such as tanks, closed containers, pressure vessels of all types, pipe lines and piping systems, where absolute tightness of all joints is essential, the application of internal pressure affords a convenient means of determining the soundness of the welds. Pressure tests are applied to a variety of finished welded products as a part of routine production under procedure control. Such tests give definite assurance that the products will give satisfactory service under the operating conditions for which they were designed. Pressure tests are also frequently required in qualifying welders for work on pressure piping systems such as high pressure steam lines.

Wherever possible, hydrostatic pressure should be used, as it has several definite advantages, which are listed below:

First, the pump does not need to be so large, since water can be compressed only slightly. The vessel is filled with water at ordinary pressure before bringing the pump into action.

Second, high pressure can be obtained more easily than in any other way.

Third, and of greatest importance, in case of sudden release of pressure there is little tendency for the parts to be thrown about violently.

Hydrostatic Pressure Test.—The equipment necessary for making hydrostatic tests consists of a small pump, a pressure gage and some piping connections. Suitable pumps for this purpose are made small enough so that they can be easily carried and the prices are quite moderate. Such pumps are used by boiler inspectors in their routine work of testing boilers. The pump illustrated in Fig. 3, or even a smaller type, is suitable for an ordinary shop and can also be used in the field, since the pressures up to 6000 lb./in.^{2} are easily obtained.

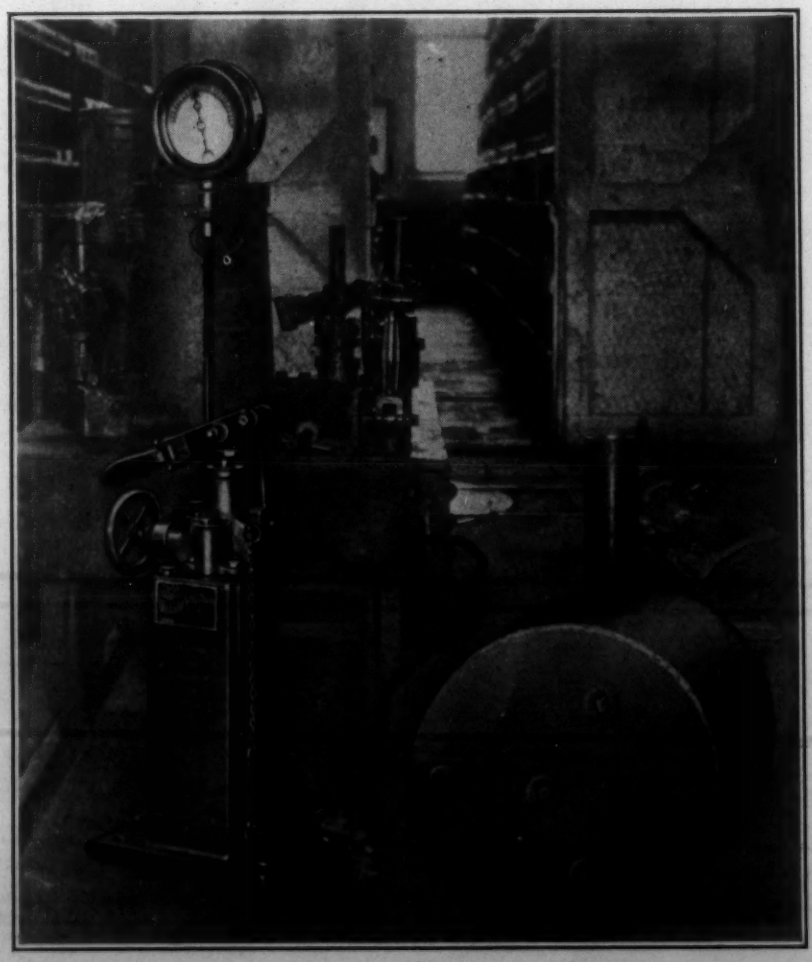


Fig. 3—Pump for Hydrostatic Pressure Test

In applying the test to pressure vessels and other closed containers, all lower openings and outlets are first closed and the vessel is filled completely full of water, making certain that no air pockets are left. Upper outlets are then closed. After connecting the pressure line to the tank, the pump is operated until the gage shows the desired pressure. This is usually at least one and one-half times the normal working pressure.

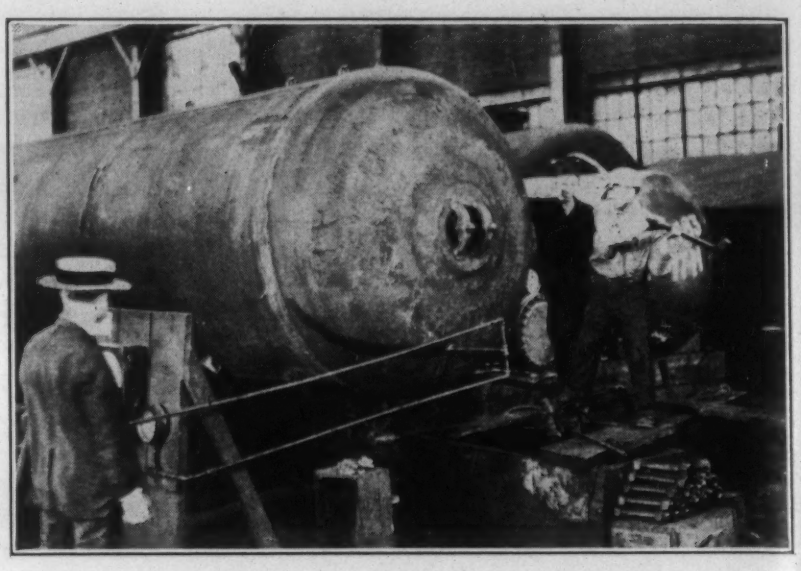


Fig. 4—Pressure-Impact Test of Pressure Vessel

In the case of pressure vessels, procedure control specifications call for a hammer test while the vessel is under hydrostatic pressure of twice the designed working pressure, Fig. 4. The weight of the hammer in pounds is equal to the shell thickness in tenths of an inch and the blows must be struck at 6″ intervals on both sides of the weld for the full length of the seam. Each seam is then given a thorough visual inspection. Following the hammer test, the hydrostatic pressure is raised to three times the designed working pressure and the seams again inspected. This pressure-impact method is used as a means of testing the strength and soundness of welds for high pressure service.

Pressure Qualification Test.—Qualification tests for work on high-pressure steam piping systems frequently specify pressure tests as part of the requirements. A typical test is given in a procedure control for welded construction of a 400-lb. pressure superheated steam-piping system, maximum temperature 750° F. See Fig. 5.

This test requires the welding of the joints in one pipe bomb to be made up of 6 or 8″ extra-heavy pipe containing two circumferential position butt welds approximately 8″ apart,

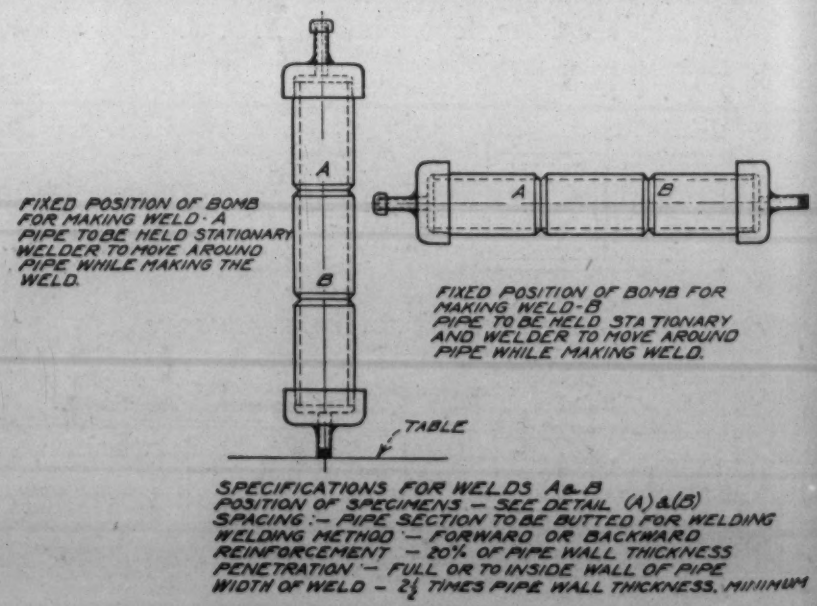

A
B
FIXED POSITION OF BOMB FOR MAKING WELD-A PIPE TO BE HELD STATIONARY WELDER TO MOVE AROUND PIPE WHILE MAKING THE WELD.
A
B
FIXED POSITION OF BOMB FOR MAKING WELD-B PIPE TO BE HELD STATIONARY AND WELDER TO MOVE AROUND PIPE WHILE MAKING WELD.
TABLE
SPECIFICATIONS FOR WELDS A&B
POSITION OF SPECIMENS — SEE DETAIL (A) & (B)
SPACING :— PIPE SECTION TO BE BUTTED FOR WELDING
WELDING METHOD — FORWARD OR BACKWARD
REINFORCEMENT — 20% OF PIPE WALL THICKNESS
PENETRATION — FULL OR TO INSIDE WALL OF PIPE
WIDTH OF WELD — 2½ TIMES PIPE WALL THICKNESS. MINIMUM

Fig. 5—Specifications for Pressure Qualification Test

Fig. 6—Welded Bull Plug Closes Line for Test

one of the joints to be welded with the bomb lying horizontally, the other to be welded with the bomb vertical. The bomb shall not be rotated during welding. The preparation of the joint shall coincide with the welded joint detail, as shown on the engineer's drawing. Weld reinforcement to be 1/8" gradually tapered where it approaches the base metal. Penetration shall be to the inside wall of the pipe. The ends of the bomb are to be closed in a suitable manner to withstand the test pressure to which it shall be subjected. At completion of welding and after the bomb has cooled to room temperature, the bomb shall be subjected to a hydrostatic test of 600 lb./in.^{2}, or one and one-half times working pressure, after all air has been expelled therefrom. While under this pressure the welds shall be struck with a 4-lb. sledge at four equidistant points, the blows being struck with a full-arm swing. Under these conditions the welds shall not leak or develop any visible imperfections.

Air Pressure Test.—For certain types of work, practical considerations make it undesirable to use hydrostatic pressure for testing. In the case of pipe lines for oil and gas, for example, it would frequently be difficult to obtain the large volumes of water necessary to fill long sections of line under test. In addition, there would be the difficulty of draining

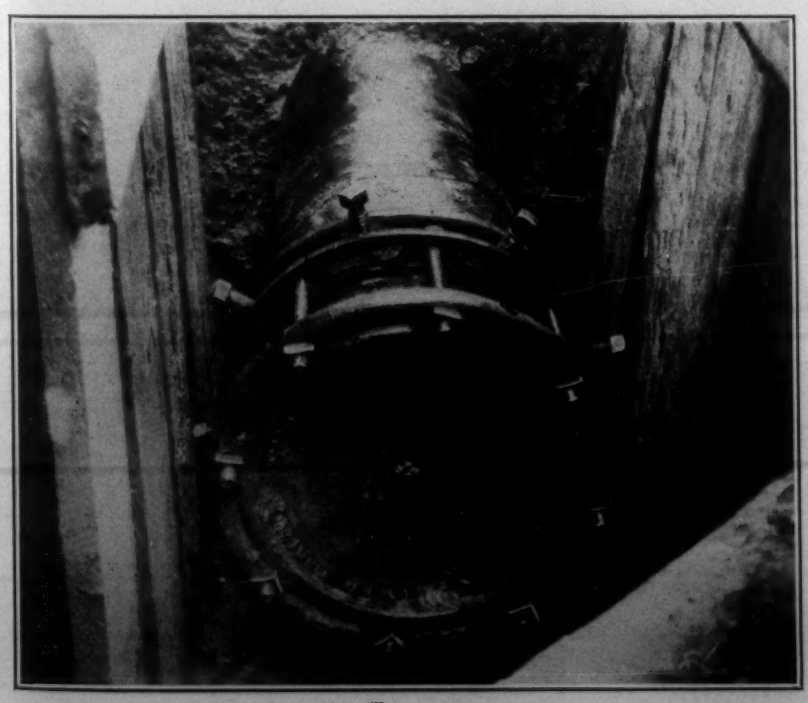


Fig. 7—Special Type of Bull Plug

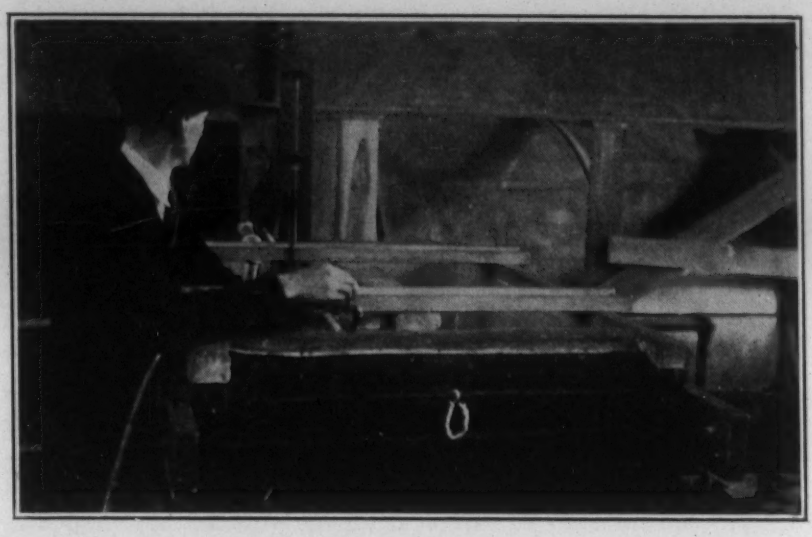


Fig. 8—Low Pressure Test of Aluminum Tank

off and pumping out the water after the test was completed. It is customary to test such pipe lines with air pressure because it is more convenient to use.

After blanking off a section of line by means of a bull plug Fig. 6, or other suitable closure, Fig. 7, and attaching pressure gages, compressors are placed in operation until the test pressure is built up in the line. Each weld is then painted with soapy water and carefully inspected for bubbles which would indicate pinhole leaks. Test specifications may also require that each weld be hammered vigorously while under pressure and then be tested again with soapy water.

In addition, gas lines are frequently required to hold the test pressure over a period of 24 hours or more, recording pressure gages being attached to the line to register changes in pressure. In the results, allowance must be made for temperature fluctuations.

Testing Low-Pressure Tanks.—Air is also used for low-pressure testing of tanks, particularly the aluminum fuel tanks used in aircraft. These tanks are tested with 4–5 lb./in.^{2} air pressure. To determine the presence of possible pinhole leaks, the welds may be painted with soapy water or the entire tank submerged in a large vat of water, Fig. 8.

Inspection of Etched Sections.—In pipe line work some method of cutting test specimens from welds in the line itself is very desirable. Splendid results have been obtained with a portable keyway slotting machine, Fig. 9, fitted with two thin milling cutters and a spacer. The procedure of handling this weld cutting machine may be along the following lines:

Within a day or two of a man's employment, the chief

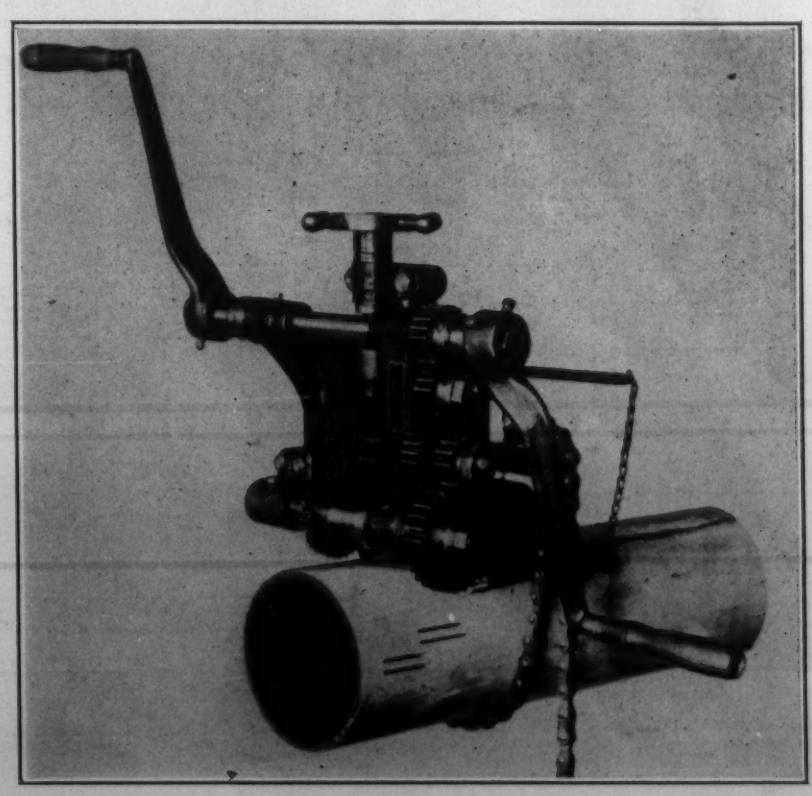


Fig. 9—Slotting Machine

inspector will mark out one of his welds and may mark a particular spot on the weld, such as the final tie-in. Then in due course of taking weld samples, the slotting machine is brought to this weld and set up on the pipe at any reasonable angle, from 45° on either side to the upright position.

Two men then operate the handles which transmit power through gearing to the milling cutters. The operation of cutting a single specimen should not exceed ten minutes on pipe 3/8" thick.

When the cut has been made, a small drill, a cold chisel or a cutting blowpipe can be used to cut across the ends of the specimen so that it can be removed. The welder's number should be stamped on one side for identification. The specimen should then be rubbed on a file held flat in a vise or backed up by a flat surface. This will give a flat surface finish on one side of the specimen, whereas the opposite procedure of rubbing a file over the specimen will not. Subsequently to filing, the specimen should be lightly rubbed on fine emery paper, and then should be etched in a 10% solution of ammonium persulphate.

Visual inspection of the etched specimen will show the soundness and quality of the weld metal.

Reheating of Welds.—A non-destructive test capable of application to light gage sheet metal products which cannot be subjected to pressure test is used by a manufacturer of high-grade automobiles. The method may be illustrated as applied to steel welds in 20-gage steel sheet in the cowl apron.

Using an oxy-acetylene welding blowpipe with a fairly large head, the inspector heats the entire length of the seam gradually and evenly to a medium red, Fig. 10. As the weld is thicker than the adjacent sheet metal, it does not heat up as rapidly as the sheet. A perfect weld will show as a uniform, unbroken darker stripe in the heated area. The presence of any defective places in the welds due to incomplete penetration, blowholes, cold shuts or laps will be indicated by bright spots in the relatively darker weld area. Where thorough fusion has not been obtained between base metal and weld metal, these sections will also show up bright while the rest of the weld will remain dark. The inspector melts out any defective spots with the blowpipe and returns the part to the operator for rewelding. Experience has shown this method to be rapid, accurate and economical.

Tests for Ductility

Ductility is a desirable characteristic of weld metal. It may be measured simply and accurately by means of a special bend test.

Bend Test for Ductility.—This test has the advantage of not requiring elaborate or expensive equipment and of this being available to even the smallest shop. All that is required is a vise, machinist's hammer and a flexible metal scale graduated preferably in hundredths of an inch. Test specimens are prepared by welding together two pieces of steel plate, usually 3/8" thick, with a single vee weld.

The plate is next cut into coupons about 1 or 1 1/2" wide by 5 or 6" long.

These test coupons are first prepared by grinding or machining down the weld, especially if it has been reinforced, then laying off the weld and adjoining metal very carefully, using center punch marks. These may be spaced 1/4" as shown in Fig. 11.

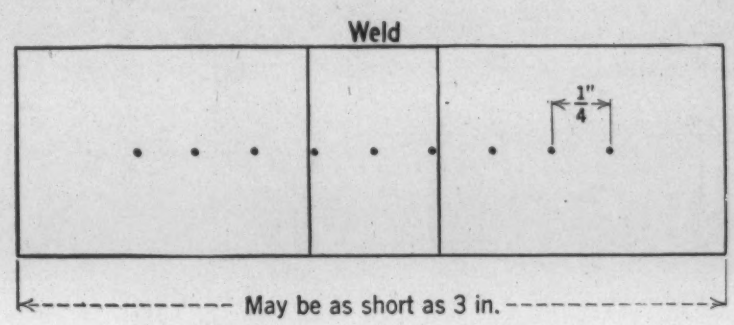


Fig. 11—Specimen Prepared for Bend Test

The sample is next placed in an ordinary machinist's vise, the jaws of which should come about 1" from the punch mark, and is struck with a hammer and bent over at an angle of about 10°. The coupon is then reversed and the opposite end is bent in the same direction. It is best not to get the jaws of the vise too far from the weld metal in this hammering test because the metal outside the weld will bend and the weld metal itself remain unaffected, thus making the test worthless. It is always necessary for the greatest part of the bending to come in the weld metal itself. The coupon is then bent in the vise, as shown in Fig. 12. This allows the bend to occur freely, which is essential for accurate and consistent results. In case the vise does not extend enough to take the coupon endwise in its jaws, the coupon can be placed between the two jaw shanks to start. If the coupon does not start to bend immediately, a good plan is to exert additional pressure by means of a length of pipe slipped over the vise handle to give extra leverage.

As soon as the first crack in the weld metal is observed the bending is stopped and the distance between the punch marks measured with a flexible steel scale reading to hundredths of an inch. When the original distance between the

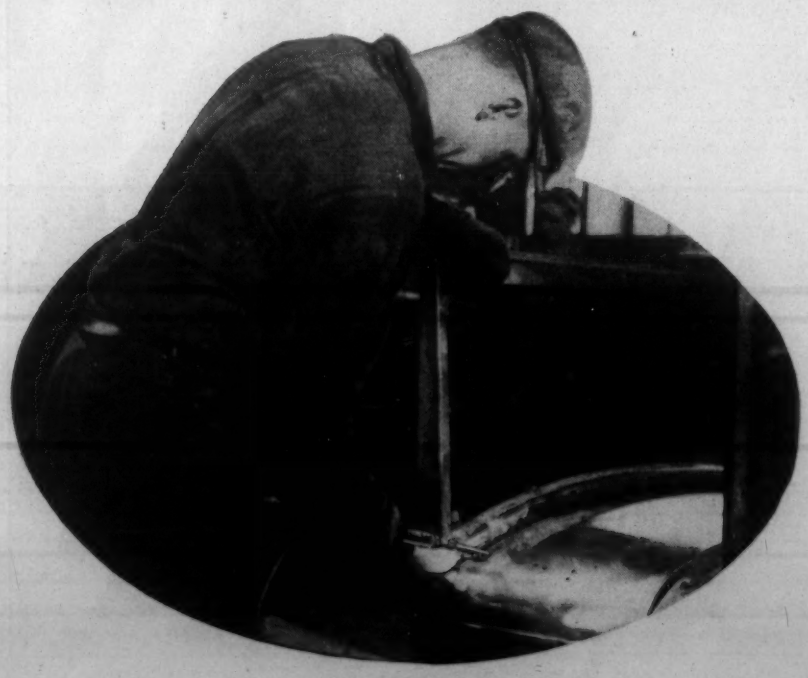


Fig. 10—A Non-Destructive Test

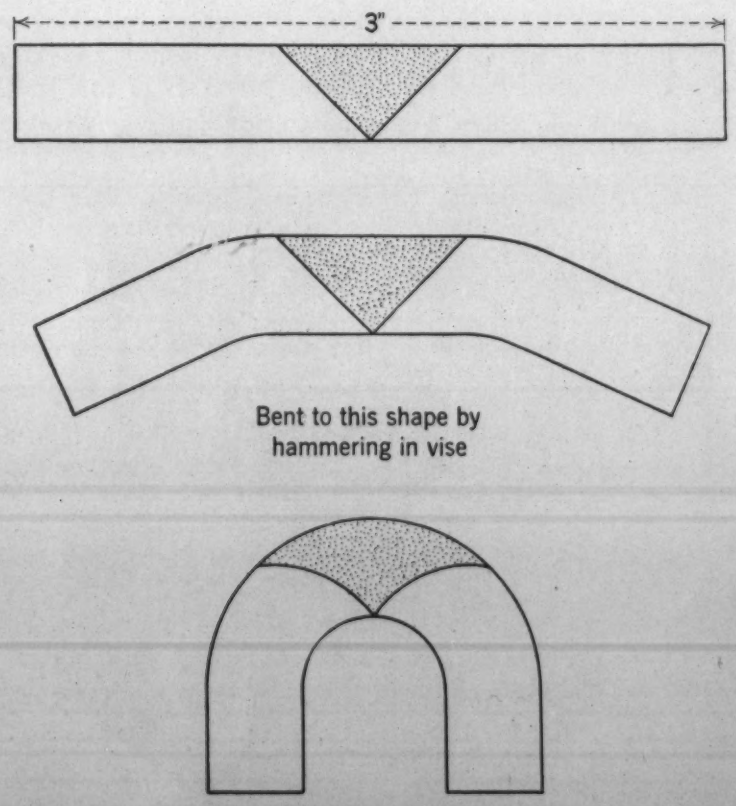


Fig. 12—How Bend Test Produces Elongation

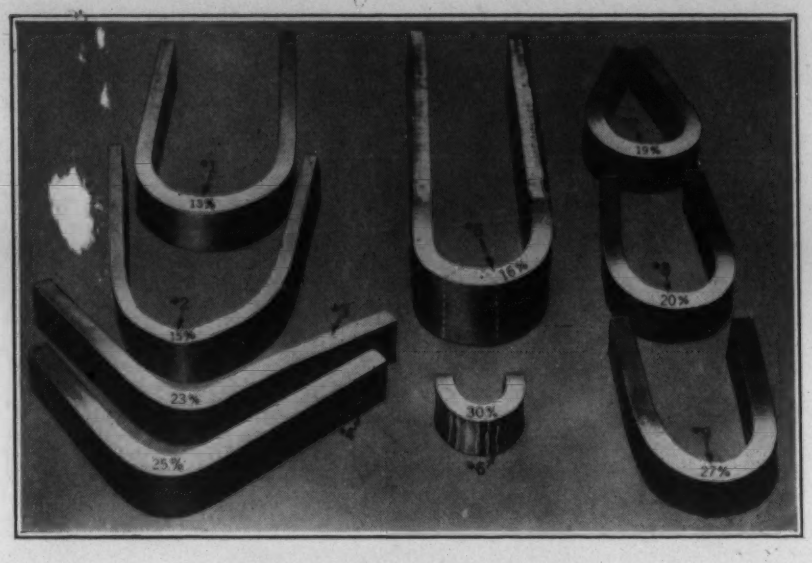


Fig. 13—Results of Bend Test

marks is 1″, the percent of elongation is identical with the number of hundredths of an inch in excess of 1″ in the final measurement. Thus, if the first measurement between the points was 1″, and the final measurement was 1.17″, the elongation was 0.17″, or 17%. Results are shown in Fig. 13.

Careful measuring of elongation by the new method will show exactly the amount of ductility in the weld metal. Cracks should appear first in the weld metal of a specimen in which the base metal and the weld metal have been properly fused, and the coupon correctly prepared for the bending test as in Fig. 12.

For purposes of comparison, and to judge the ability of welders, the following results have been taken at random from some test coupons. This series of welds, made with a mild steel rod in boiler plate 3/8″ thick, ran from 26–30% elongation, with an average elongation of about 28. Welds made with rod for high strength welds while stronger, were a little less ductile, showing an elongation of from 15–20%, with a general average of about 15. These welds were the ordinary run of good welders' work and can be considered of high standard as to ductility. In larger shops where periodic testing by the bend test is done, a further check may be made by use of what is known as the bend test extensometer. This consists of a very sensitive micrometer gage, with two fixed points, one inch apart, and a center movable point which registers in percentage directly on the dial.

Special Tests

For certain purposes it is occasionally desirable to determine other properties of weld metal. Most of these tests are specialized and require laboratory facilities.

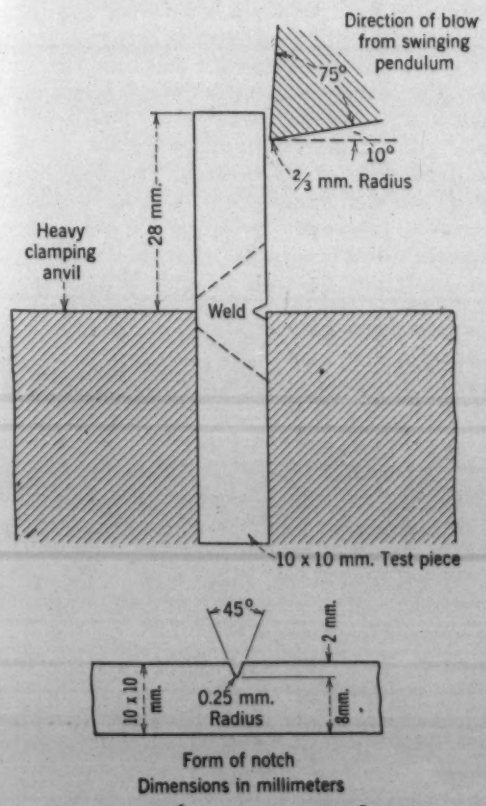


Fig. 14—How an Impact Test Is Made

Resistance to impact or shock is a valuable property for certain applications, such as the welds made in double-length pipe which is subjected to considerable handling before it reaches the line. The standard Izod impact test consists of fracturing the projecting end of a notched specimen by striking with a swinging pendulum. Striking with the pendulum produces fracture with one blow under cantilever action. The energy in foot-pounds absorbed in producing fracture is taken as a measure of the resistance of the metal to fracture when subjected to shock, Fig. 14.

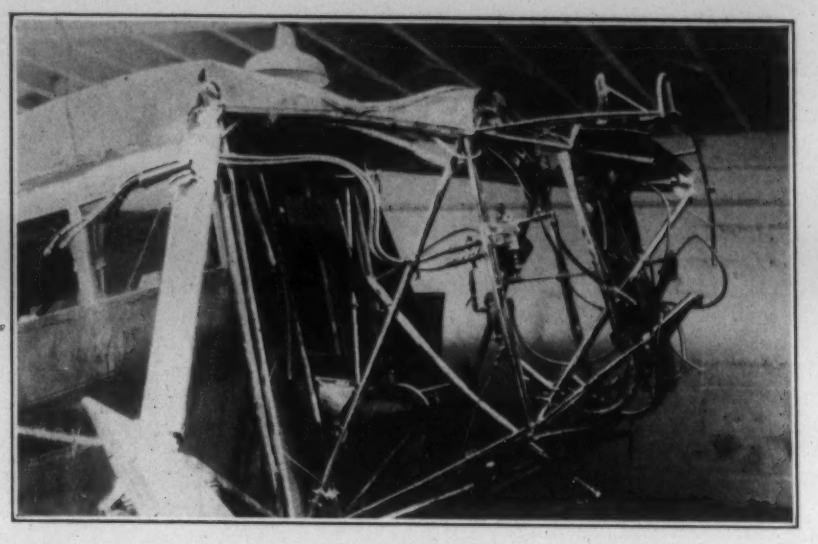


Fig. 15—Welds Held When Motor Tore Loose

It may also be desirable at times to determine the behavior of weld metal under conditions that may produce fatigue or the resistance of the weld to corrosion. Standard tests for this are also available.

Accidental Tests

It is obviously impossible to determine the ultimate strength of the welds in every finished assembly, as this would involve destruction of the part tested. An occasional assembly may be tested to destruction particularly during experimental work in modifying or improving designs but the bulk of production must be tested by methods that do not impose stresses above the yield point.

At times, however, finished assemblies are subjected to most convincing tests accidentally after being placed in service. Such tests prove the worth of welds made and tested under procedure control. Fig. 15 shows a motor base of an airplane which suffered an accident of this sort. While flying at a height of about 2000 ft. the propeller of the plane broke. The eccentric loading of the motor due to this fracture caused the motor to tear itself loose from the motor base framework at the place indicated in the illustration. The pilot glided the plane safely to the ground without injury to himself or seven passengers he was carrying at the time. This photo shows that the weld held up even when the base metal gave way.

Fig. 16 shows the fuselage of a plane which cracked at the start of a flight and dove to the ground from a height of about 75 ft. Although the entire front part of the plane was smashed in, welded aluminum tanks in back of the pilot's seat held without springing the least leak. The welded steel tubular framework kept these tanks from crushing the pilot between their load of 300 gal. of gasoline and the hot motor.

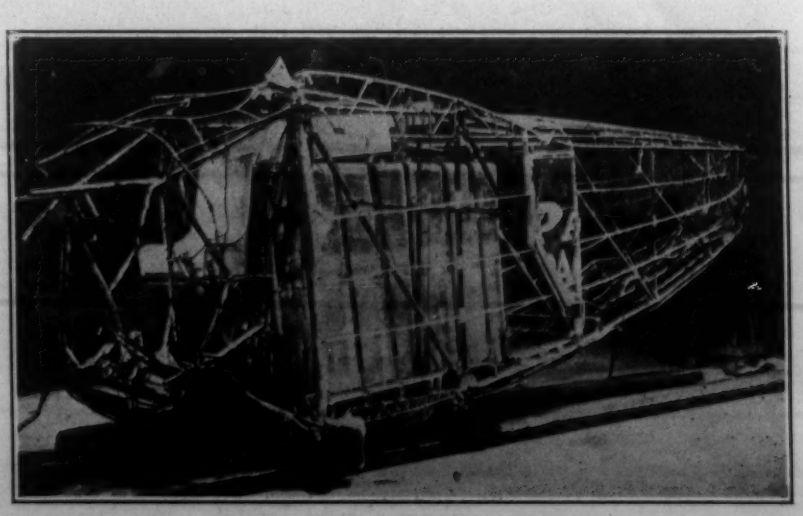


Fig. 16—Welds in Fuselage and Tanks Were Intact

Fig. 17—Washout Tests Oxwelded Pipe Line

If any of the welds had failed the pilot would have been instantly killed.

Other tests have been seen in accidents occurring to pipe lines. Fig. 17 shows a portion of a pipe line which was washed out in the failure of a dam. The welded joints held while the pipe itself gave way.

The entire subject of testing welds offers unlimited opportunity for study and research. The welding industry is looking forward to a simple, non-destructive method for testing various types of welds. Magnetic, X-ray, stethoscopic and other methods are all being carefully studied.

However, through the application of procedure control, splendid results are being obtained with the test methods now available as outlined above. Several years' experience in many fields has shown that welds of uniformly high quality can be produced consistently by welders who are properly qualified and given periodic tests and who are properly supervised in accordance with procedure control principles.

Procedure Control in Welding

Amazing strides have been made recently in regulating uniformity and quality in hand welding, as is brought out in the article on Methods of Testing Welds in this issue. However there cannot be 100% testing of all welded products and it is still necessary to assume that the sampling is adequate.

It appears to us that more stress should be laid on fully automatic welding rather than hand welding. In electrical resistance welding, if the composition and dimensions of the welded parts are the same, and the pressure, the current and the rate of welding the same, all of which can be observed and controlled by meters and automatic control devices, then there is real assurance that the test result found on one weld apply also to another.

Other methods of welding can be almost as well controlled if done on a machine basis. We look for greater development and use of welding machines, and for the relegation of hand welding to those joints whose failure will not have serious results.

Pending the perfection of automatic machine methods procedure control of hand welding is the only way to handle the hazard of the personal equation. The best procedure control we have heard of is in an aircraft factory where each welder has to take a ride in the plane he has helped to weld. – H. W. G.

Correction: In the Current Metallurgical Literature Review of June issue on page 568 the following omission was made in the abstract, "The Physical Chemistry of Steel Making, Deoxidation of Steel with Aluminum." G. R. Fitterer was omitted as one of the authors. These should read "C. H. Herty, Jr., G. R. Fitterer & J. M. Bryns.

Increased Production of Aluminum in 1929

New aluminum produced in the United States during 1929 amounted to 225,000,000 lbs., valued at $51,864,000, as compared with 210,000,000 lbs., valued at $47,899,000, produced in 1928, according to a statement of the United States Bureau of Mines, Department of Commerce. The principal producing plant was that at Massena, New York, where approximately 42% of the metal made in the United States was produced. Other works are at Niagara Falls, New York; Alcoa, Tennessee; and Badin, North Carolina.

According to the *Engineering and Mining Journal*, the domestic price of new aluminum ingot 99% pure was 24.3 cents a pound during the entire year 1929. Prices in the outsied market for metal 98–99% pure held throughout the year at 23.9 cents a pound.

Imports of aluminum metal, scrap and alloy in 1929 were 28% more in quantity than in 1928. Imports of plates, sheets, bars, etc., in 1929 decreased 16% in quantity and imports of hollow ware were slightly less than in the previous year. Imports of "other manufactures" of aluminum increased 15% in value in 1929, as compared with imports of similar products in 1928.

Aluminum Imported in 1928 and 1929
(General Imports)

	1928		1929	
Class	Lbs.	Value	Lbs.	Value
Aluminum:				
Metal, scrap and alloy	37,895,832	$7,736,412	48,370,921	$8,973,233
Manufactures:				
Plates, sheets, bars, etc.	26,275	10,738	22,010	8,724
Hollow ware	123,320	69,876	123,024	71,046
Other manufactures	.....	761,116	.....	872,908

Exports of aluminum ingots, scrap and alloys in 1929 decreased 74% in quantity. Export of tubes, moldings, castings and other shapes increased 146%, as compared with 1928, and exports of plates, sheets, bars, etc., increased 23%. The value of table, kitchen and hospital utensils exported in 1929 increased 10%, and that of "other aluminum manufactures" increased 14% as compared with 1928.

Aluminum Exported in 1928 and 1929

	1928		1929	
Class	Lbs.	Value	Lbs.	Value
Aluminum:				
Ingots, scrap and alloys	2,390,498	$443,895	613,366	$117,345
Plates, sheets, bars, strips, and rods	13,337,783	3,314,883	16,418,751	4,032,194
Tubes, moldings, castings, and other shapes	1,003,957	398,250	2,466,508	738,376
Table, kitchen and hospital utensils	.....	643,205	.....	708,467
Other aluminum manufactures	.....	2,091,307	.....	2,374,703

The Chairman of the Board[1] of the Aluminum Company of America has stated that the two most interesting developments in the aluminum industry during 1929 were the completion of a manufacturing technique that made possible the rolling of large structural shapes from high strength alloys, and the adoption of aluminum as a new decorative and utility metal by architects.

Aluminum shingles, roofing and corrugated sheets which are standard products of growing importance, have been joined in this field by ornamental castings for crestings, spandrels, cornices, finials and other metal accessories. Several recently-constructed office buildings carry from fifty to a hundred tons of aluminum mainly in the form of cast spandrels or ornamental exterior wall plates and sills. In aviation, the average amount of aluminum per plane in 1929 increased greatly over preceding years. Other products of aluminum reflected in their volume the high production scales of the fields to which they go, including the electrical light and power, pigment for paint, cooking utensil, household machinery, furniture and chemical industries.

[1] Arthur V. Davis, "Aluminum Made Big Gain in 1929," *Daily Metal Reporter*, Jan. 21, 1930, pages 3 and 13.

A 32-page artistically printed booklet contains views of the new laboratory of the Aluminum Company of America at New Kensington, Pa. The photographs of the exterior of the building illustrate some of the uses which are being made of aluminum in architectural decoration and construction. Other views show the chemical, metallographic and physical laboratories. A view of the technical library, an essential tool for research work, is also shown. A copy of this booklet can be obtained from the Aluminum Company of America, Oliver Building, Pittsburgh, Pa.

The Prest-O-Lite Company, Inc., 30 East 42nd Street, New York, N. Y., announces the opening of their new plant for the manufacture of dissolved acetylene at 1240 Stewart Avenue, S. W., Atlanta, Georgia. The new plant is designed to take care of the demand occasioned by the increased use of the oxy-acetylene process in this industrial area.

Corrosion Meeting of the Deutsche Gesellschaft für Metallkunde

Berlin, May 15, 1930

Prof. Dr. O. Bauer, Chairman of the Society opened the convention with a welcome to all members and guests. He pointed out that the importance of corrosion and of the technical questions connected with it, is growing steadily. The large number of participants and the interesting discussions joining the different speeches indicated that there was really a general need for a common conference on the different problems of corrosion.

Dr. G. Masing (Berlin) read the first paper entitled "Basis of the Corrosion Process." Corrosion signifies an unintended destruction of a metallic body by chemical influences which starts from the surface. The corrosion process is thought to be an electrochemical one; it is caused by potential differences which are due to inclusions of other metals, to mechanical work or to heating effects. In the presence of electrolytes the differences in the electrical potentials affect the formation of local elements. In such spots, the material with the greatest electrolytic solution potential goes into solution. This theory affords an explanation for the appearance of pittings in corroded materials. Under certain conditions, the more electro-positive part of the dissolved metals deposits upon the surface and thus produces protective coatings. The behavior of the material largely depends upon the behavior of these coatings against further attacks. They might increase the attack as well as act in a protective way.

The "Methods of Corrosion Tests" were discussed by Dr. Erich K. O. Schmidt (Berlin-Adlershof). In order to approach the needs of practice as far as possible, the materials have to be subjected to the laboratory tests in a form and in a state that corresponds closely to the conditions of practice. The corrosive agent should also be employed according to this tendency. Before the test, the chemical analysis, the previous treatment and the physical properties must be determined. Besides this, it should be stated in detail how the samples are taken from the initial material, the location of the specimens in the original sheet being shown by a sketch. The most generally employed laboratory tests are the total immersion test, the wet and dry test, the salt-spray test and the accelerated immersion test.

After the corrosion test, the change of the surface, structure and of weight are determined and tensile tests carried out. According to the latest experiences, the estimate of corrodibility based only on the change in weight and surface does not suffice. It must be supplemented by an investigation of structure and physical properties. The tensile strength and percentage elongation has proved very useful. If constant conditions are observed the data derived from the above mentioned tests of light-metals are reproducible and give results remarkably concordant with the experiences of practice.

Dr. phil. C. Carius (Dortmund) rendered a report of the corrosion in copper-steel. The resting of copper-steel is accompanied by a deposition of metallic copper on the surface. The form of this deposit depends on exterior conditions, being either a smooth coating that adheres to the underlying metal or a loose sponge copper. When corroding in the open air the copper steel becomes coated with a tough and adherent film. Under the influence of atmosphere, this coating is transformed into basic copper carbonate and gives the copper steel a life 50% longer than that of ordinary steel.

The corrosion attack in liquids usually produces loose sponge copper on the surface of the metal. A protective action only occurs if the spongy copper becomes luted by gelatinous hydrates and if this coating hardens. The process takes place in exposure to seawater. In those cases in which a protective coating does not form, the attack goes on unrestricted, and the addition of copper effects no resistance to corrosion at all. "The Corrosion of Lead and Its Importance for the General Knowledge of Corrosion," presented by Dr. Max Werner (Wiesdorf/Niederrheim) next occupied the attention of the meeting. It has been the general opinion till now that lead must contain certain other metals in order to make it fine-grained. This opinion, however, can no longer be maintained, for even chemically pure lead is obtainable very fine-grained. The opinion, that the resistance to corrosion increases with increasing fineness of the grain is also wrong. There are metals, as for instance, bismuth, which produce a fine grain but which, nevertheless, increase the corrodibility.

Additions of other metals have quite a different effect, they cause the formation of local elements. If suitable metals are alloyed, these local elements favor the production of films and consequently lead to a certain protection against corrosion. For this purpose, it is necessary that the added metal act as cathode of the local element. A continually good protection cannot be obtained unless the coating adheres strongly to the underlying metal, otherwise a period of diminished attack would be always succeeded by a period of increased attack. Unfortunately, no methods of testing the corrodibility of lead are reliable.

Dr.-Ing. P. Brenner (Berlin-Adlershof) opened the afternoon session with a report on "Corrosion and Protection Against Corrosion of Light-Metals in Aircraft Construction." Owing to their low specific gravity but high tensile properties, aluminum alloys are employed extensively in aircraft construction. Their resistance to the corrosive attacks of atmosphere and especially of sea water is, however, restricted. The intercrystalline corrosion is the most dangerous. A considerable decrease of the tensile properties takes place without any observable change of the surface. Experiments showed that heat-treating largely influences the occurrence of intercrystalline corrosion.

As the light metals, when unprotected, are not satisfactory, the question of surface protection is of foremost importance. Due to the short life of the coat, the application of paint to seaplanes gave unsatisfactory results. The anodic treatment, developed during recent years seems to have better prospects. By this method, oxidic coatings are produced which have some resistance to corrosion when greased, and are very good priming coats for subsequent painting.

A further progress in the line of surface protection is gained by the use of duplex materials. Thin films consisting of pure aluminum or of aluminum alloys are brought upon the material by fusion welding. The resistance to corrosion of the coating thus protects the whole material. In those spots in which the base-metal is unprotected, an electrochemical action takes place which attacks the coating but which protects the underlying material. The additional application of anodic treatments still further improves the resistance to corrosion of these duplex materials.

Dr. R. Sterner-Rainer (Neckarsulm) reported on "The Corrosion of Aluminum Casting Alloys." The resistance to corrosion of commercial pure aluminum increases with increasing purity. Additions of other metals may retard as well as accelerate the rate of corrosion, sometimes they have no traceable influence. Iron and above all copper accelerate the corrosive attack, manganese, titanium, silicon and zinc are neutral, while antimony, bismuth, cadmium and magnesium increase the resistance of the material by overcoming the unfavorable influence of iron, always present in aluminum. Practical experiences showed the "KS-seawater-cast-alloy" (KS Seewasser) to be the most resistant to corrosive attacks. Silumin and all the other so-called seawater-proof alloys have very much lower corrosion resistance. Pure aluminum possesses generally the greatest stability to attacks of substances of all sorts, such as chemicals, foods, etc., but KS-seawater-cast-alloy and Silumin can be used in many cases, too. There may be many other alloys suitable for the same purposes, for no relation exists between the composition of an alloy and the rate of its corrosion. The different means for protecting the surfaces of light-metals were described briefly.

H. Röhrig (Lautawerke) gave details on "Micro-Corrosion Test on Aluminium and Aluminium Alloys." He first described researches which Cazaud carried out in exposing sections of different light-metals to the corrosive effect of seawater. The author extended these researches to other corrosive agents and came to the following conclusion. Those components which are usually deposited in a crystalline form, generally are more electropositive than aluminum itself. Therefore, they cause pitting in the presence of agents which dissolve the aluminum. Other agents may attack the deposited components and thus result in irregular destruction. In order to increase the resistance to corrosion the deposits have to be avoided as far as possible.

In the final paper H. Röhrig (Lautawerke) communicated experiences in cable-materials. On the Isle of Sylt a research-station is established for testing electrical cables. The cables are exposed both to the corrosive influence of the atmosphere and to the mechanical effect of sand-storms. Cables made, respectively, of copper, aluminum and aluminum alloys were put out before 30 months before and are even now in such a good condition that the test could be continued. After certain periods, the corrosive attack was examined and the susceptibility of the different tests was found to rise in the following order: electrical conductivity, tensile strength, percentage elongation and number of bends.—Georg Goldbach.

Metal Abrasives

By A. B. McDaniel[1]

Manufacture.—The common term "Steel" shot and grit is occasionally a misnomer, as the material may be a chilled iron product. There is, however, a product made from high-carbon steel scrap, which is melted and poured into a tank of water, where it freezes. The iron shot is generally made by melting cast-iron scrap or pig iron and blowing it into the air by a steam jet. The metal is thus converted into spherical particles which solidify on falling into a tank of water, forming shot. The larger sizes of shot are crushed to form grit.

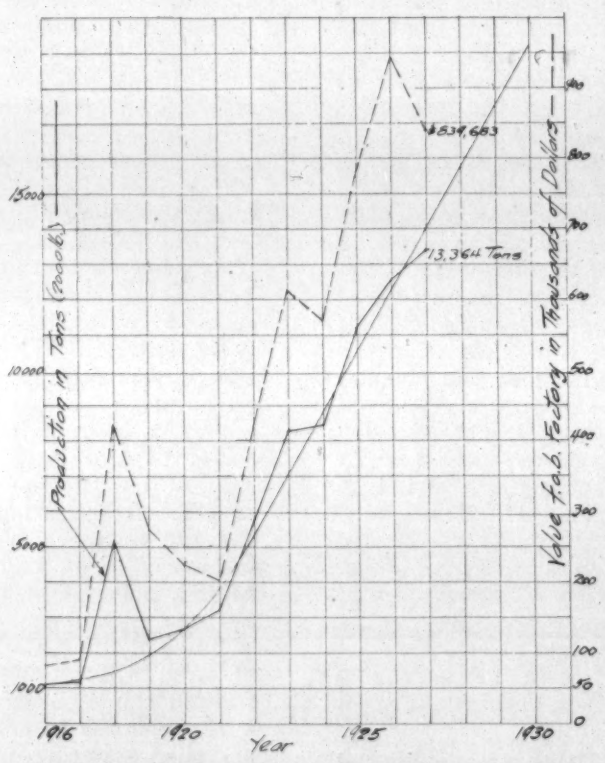
The grit is screened to various sizes, the fine product being termed "sand." There is a lack of uniformity among manufacturers as regards sizes, one manufacturer labelling a certain size shot as No. 7 that another manufacturer may call No. 5, and so on. A special committee of the American Engineering Standards Committee is now working on a standard specification to secure uniformity and standardization of product.

Some of the manufacturers of steel shot and grit are: American Steel Abrasives Co., Galion, Ohio; Globe Steel Abrasives Co., Mansfield, Ohio; Pangborn Corporation, Hagerstown, Maryland; Pittsburgh Crushed Steel Co., Pittsburgh, Pa.; Steel Shot and Grit Co., Amesbury, Mass.

Grit, shot and sand of iron and steel have been made in the United States since about 1872. There were three plants in operation in 1922, one each in Pennsylvania, Massachusetts and Ohio, employing a total of about 100 workers. These plants had an annual output of about 4900 tons in 1922. Since 1922, production has increased gradually so that at the present time (1929) it is about three times that of 1922. The following table gives the production quantities and values from 1916 to 1927, inclusive:

Shot and Grit Production in United States

Year	Output Tons of 2000 Lbs.	Value F. O. B. Factory
1916	1,073	$ 89,559
1917	1,125	93,103
1918	5,150	472,721
1919	2,360	274,200
1920	2,650	225,920
1921	3,167	202,040
1922	5,804	421,148
1923	8,229	612,140
1924	8,597	569,665
1925	11,165	780,612
1926	12,610	942,429
1927	13,364	839,683



Uses.—Steel shot and grit are used in foundries for the cleaning of castings, and also (in the place of sand) in sand blasts for the cleaning of surfaces of metal prior to painting and plating. In recent years, these metal products have been used successfully in quarries and stone working establishments for the dressing of surfaces of the softer building stones such as limestone.

Steel shot and grit have the advantage over sand in a sand blast equipment that they are more durable, have a longer useful life, obviate the dust hazard and nuisance, require less material and give more continuous service. Their economic useful efficiency is about 25% greater than that of natural sand for cleaning castings in heavy foundry work.

On some classes of work, such as preparing surfaces on nameplates and ornamental work made of non-ferrous metals, fine natural sand is preferable to secure a velvet surface finish. It is possible, however, that very fine metal sand might be similarly and satisfactorily used.

In the use of shot and grit, care must be taken to have the material dry to prevent clogging the discharge hose. Some users suggest using three sizes of grit to secure greater impinging surface and more uniform cutting—replacing the coarsest material from time to time.

A recent use has been that of a few structural steel plants in the cleaning of rust and scale from steel plates prior to layout work in the shop.

Shot should always be used with the non-ferrous metals such as brass, bronze and copper, and grit for iron and steel work.

[1] Secretary-Treasurer, The Research Service Inc., Washington, D. C.

The Federal government uses shot and grit in the foundry at the Bureau of Standards, at the Washington Navy Yard and on the Panama Canal. The total consumption is about 100 tons a year. The balance of the annual production (about 15,000 tons) used in the United States, is consumed by the larger privately operated foundries and a few stone working establishments.

It should be noted here that the amount of shot and grit imported into this country is about 1% of the total amount used annually in this country. For example, in 1928, the estimated production was about 15,000 tons, while about 212 tons were imported. The following table[2] gives details of the imports of iron and steel shot, grit and sand during the past decade:

Calendar Year	Rate of Duty	Quantity Pounds	Value	Duty Collected	Value Per Unit of Quantity, Cents	Actual or Computed Ad Valorem Rate %
1919	30%	1,020,804	$17,718	$5315	1.7	30.00
1920	30%	893,804	16,320	4896	1.8	30.00
1921	30%	192,800	4,774	1432	2.5	30.00
1922[a]	30%	.....	....	...	...	30.00
1922[b]	3/4¢ per lb.	220	16	2	7.3	10.31
1923	3/4¢ per lb.	437,600	7,521	3282	1.7	43.64
1924	3/4¢ per lb.	243,419	4,413	1826	1.8	41.37
1925	3/4¢ per lb.	453,102	12,164	3398	2.7	27.94
1926	3/4¢ per lb.	256,843	5,968	1926	2.3	32.28
1927	3/4¢ per lb.	87,000	2,428	652	2.8	26.87
1928	3/4¢ per lb.	424,177	7,812	3181	1.8	40.72

[a] Jan. 1–Sept. 21.
[b] Sept. 22–Dec. 31.

Most of the imported shot and grit comes from Scotland and consists of sizes little used abroad and of general use in this country. It is noteworthy that the annual imports in 1928 were only about one-tenth of the amounts imported in 1914, largely due to World War conditions.

Only a small quantity of shot and grit is exported. The figures of exports are not available.

Between 1892 and 1912 four factories began to manufacture shot and grit. During this period three factories were forced out of business by severe competition, especially from production in Scotland, which had begun about ten years previous. During the World War period, 1914–18, imports slackened and then stopped, and production in the United States became firmly established. The fact that imports have not regained their prewar status indicates the increasing stability of this industry.

There is a wide field of use for shot and grit that has not been developed. For example, in the Federal government service, only one of ten navy yards and no arsenal of the War Department uses steel shot and grit. The Panama Canal is only beginning to use this material. It is possible that through properly directed sales promotion 1000 tons of shot and grit could be sold annually to Uncle Sam. In the non-governmental field there is still larger opportunity for promotion work. The figures for production in this country will probably run close to 16,000 tons for 1928, and the uniform curve in the chart shows the probable rate of production until 1930.

Under a vigorous sales promotion campaign, however, the sales should greatly increase and turn this production curve upwards toward the vertical.

Research.—A recent investigation of the field of metal abrasives indicates the great need and importance of research.

A comprehensive and properly planned series of tests would show the economic efficiency of the use of shot and grit over natural sand for various processes in the foundry, stone cutting plant, metal works and similar concerns. These tests should also indicate the best grades and kinds of material for different uses. Very little is known about this subject at the present time.

From 1925–1926, there was a drop in price of from 5–3 cents per pound for shot and grit in carload lots. This is shown on the accompanying chart, with a value drop from $942,429 in 1926 to $839,683 in 1927. This condition emphasizes the importance of research in two fields; to improve and cheapen production methods, and to find new fields of use. It is probable that a wide use for the finer materials could be found in the chemical industries.

[2] Summary of Tariff Information, 1929, Schedule 3—Metals & Manufactures of U. S. Tariff Commission, 1929.

Extended Abstract

Selected articles that appear to be of outstanding importance or interest will be abstracted in this section at greater length than Abstracts of Current Metallurgical Literature. The important points will be given fully enough to obviate for the purposes of most readers, the necessity of going to the original article, but in a distinctly condensed form. These abstracts are not critical.

Corrosion of Open Valley Flashings[1]

The prevention of corrosion of the vulnerable part of a copper roof is of direct interest to users of roofing. A simple method of construction is suggested that is estimated will increase the life to at least 50 years under the most severe service conditions.

This paper has, however, a wider interest than to the user of copper roofing. Lessons can be learned from it in regard to corrosion problems in general. Failures occurred in practice only in atmospheres containing both sulphurous fumes and salt air. Construction that favored slow drying, i. e., long contact with moisture, favored corrosion. Laboratory tests reproducing these conditions in controllable fashion gave positive results that can apparently be applied directly to practice. Too much so-called corrosion testing in the laboratory has no direct relation to the actual conditions of service and gives misleading results. Intelligent analysis of the service conditions will often allow the reproduction of those conditions in the laboratory with far more useful results than would come from the use of some so-called "Standard" corrosion test that does not relate directly to actual service.

For several years the Bureau of Standards and the Copper and Brass Research Association have been conducting a joint investigation of problems concerning copper roofing, the chief object of the investigation being to increase the usefulness of copper as a building material. One of these problems was to determine the cause of a peculiar form of localized corrosion which sometimes occurs in sheet copper when used for the flashing of open valleys and to find some means for eliminating it so that the service life of a roof will not be limited by the life of the flashing. Further, it was important to be able to recognize the circumstances under which such corrosion is likely to be serious enough to warrant precautionary measures.

The term *line corrosion* is defined in the paper as a localized corrosion occurring in a narrow band from $^1/_{32}$–$^3/_{32}$″ wide in the flashing located under the very edge of the overlying roofing. Fig. 1 shows the essential feature of an open valley where the flashing is applied in the usual manner. Sections of a valley flashing which had failed in service are illustrated in Fig. 2. These specimens were removed

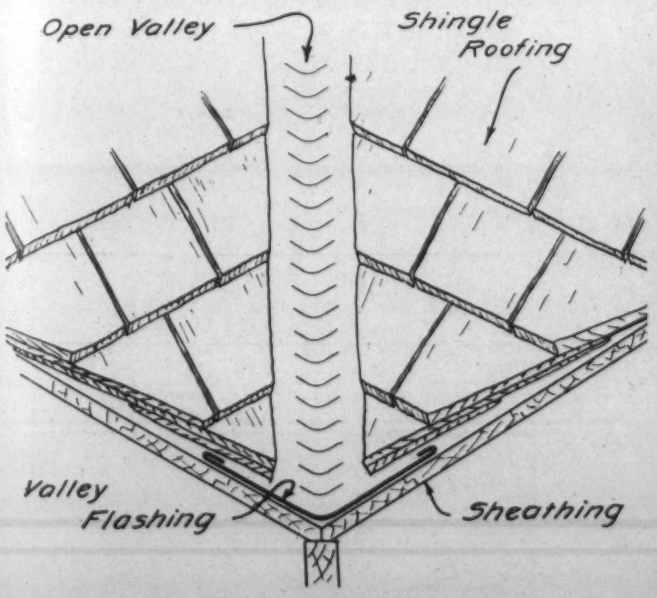


Fig. 1—Diagram of an Open Valley

from a residence in Hackensack, New Jersey, about 16 years after the construction of the building. The roofing was "Creo-dipt" shingles and the flashing was 16 oz. Roofing Temper (soft) copper (16 oz./ft.^{2}, 0.0216″ nominal thickness). The example is given as typical of other failures except that in most cases repairs are made as soon as the flashing has been penetrated at any point and before the continuous crack has been formed.

The photograph shows the appearance of the under surface of the flashing. Attention is called to the extreme localization of the corrosion. The copper was penetrated in two narrow bands $^1/_{16}$–$^3/_{32}$″ wide, the rest of the surface was in good condition.

The opinion is held by many that chemical action, due to the wood shingles, is directly responsible for the corrosion of valley flashings. However, failures very similar in appearance to that shown were reported where no wood shingles were present.

Service data were insufficient to draw any conclusions regarding the relation between failures and their location. It was noted, however, that on several specimens received for examination, the roofing shingles were almost black with soot and cinders from coal smoke.

Two series of tests were carried out. In the first, sample roofs about 30″ square were mounted on 1–3 pitch (1″ rise for each 3″ horizontal). The test flashing was placed along the lower

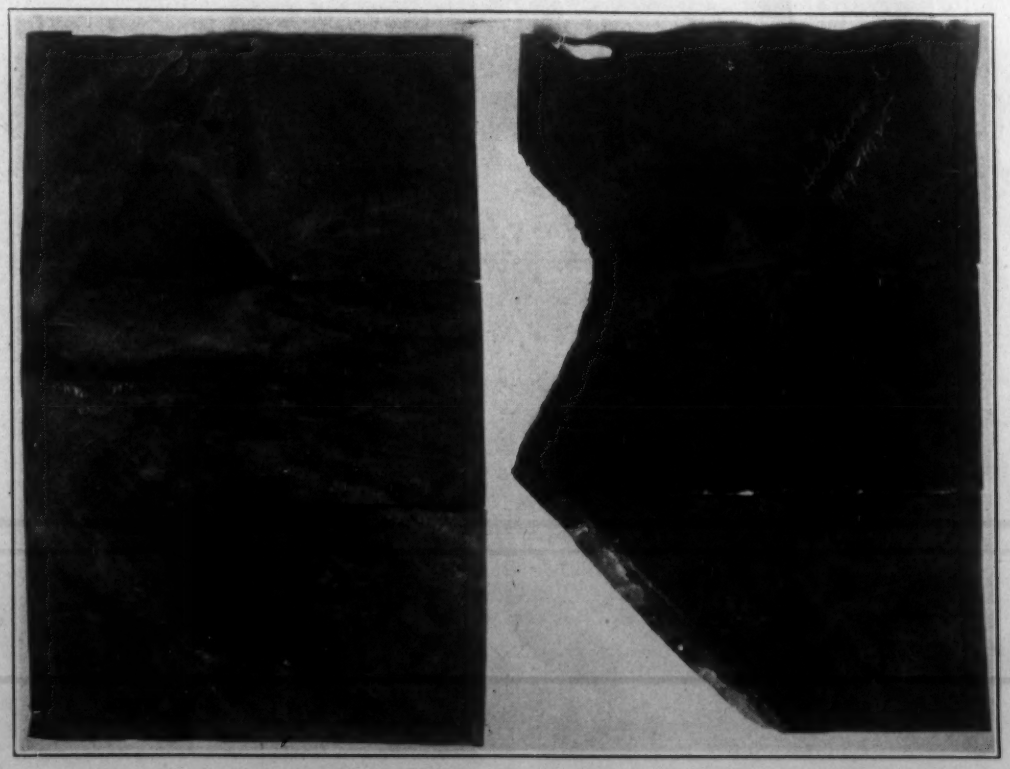


Fig. 2—Sections of an Open Valley Flashing Which Had Failed in Service. Approximately $^1/_4$ Size

edge of each specimen. Commercial (electrolytic) sheet copper of 16 oz. gage (0.0216″), was used. This gage is the one most

[1] Abstract of Paper by K. Hilding Beij, *Bureau of Standards, Journal of Research*, Dec. 1929.

Table I—Descriptive List of Specimens and Summary of Results of First Series of Tests

Specimen Number	Type of Construction*	Flashing Temper**	Roofing Material	Cycles for Failure	Remarks
1	I	R. T.	Red Cedar shingles	93	Line corrosion failure
2	I	C. T.	" " "	50	" " "
3	I	R. T.	Cypress shingles	99	" " "
4	II	R. T.	Red Cedar shingles	...	Line corrosion failure—time not observed
5	III	R. T.	" " "	...	" " " " " "
6	I	R. T.	"Creo-dipt" shingles (color green)	93	" " "
7	IV	R. T.	Slate	187	" " " —at edge of lath
8	I	R. T.	Asbestos shingles	255	" " "
9	IV	R. T.	Terra cotta Spanish tile	193	" " " —at edge of lath
10	V	R. T.	Copper shingles (9 oz. C. T.)	(93)	Copper shingles failed. No line corrosion

* See Fig. 3.
** R. T. signifies Roofing Temper (soft) copper. C. T. signifies Cornice Temper (hard) copper.)
All specimens on pitch of 1:3 (rise of 1 inch to every 3 inches horizontal).

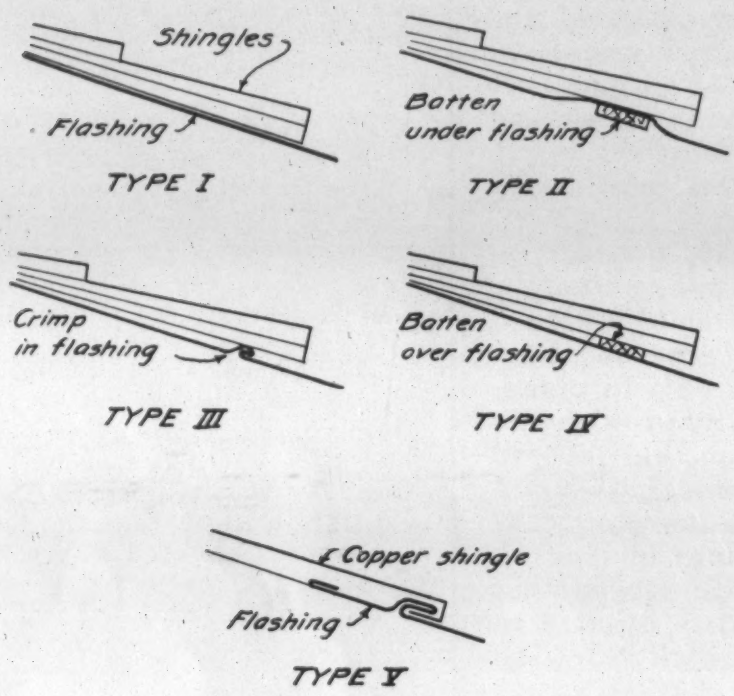


Fig. 3—Types of Construction for Open Valley Flashings

commonly used for roofing purposes. Soft copper (Roofing Temper) was used on all specimens except No. 2 which was flashed with hard (Cornice Temper) copper. A descriptive list of the specimens studied is given in Table I and diagrams of the various methods of construction in Fig. 3.

Fig. 4, a photograph taken while tests were in progress, gives a clear idea of the testing method. By suitable arrangements a suitable corrosive solution was caused to flow uniformly at any desired interval over the entire width of the specimens and flowed over practically all of the roofing before striking the flashing.

In the first series five tests were made, all on the same set of specimens; (1) tap water was recirculated continuously over the specimens for 7 hours each day, (2) a 0.4% solution of sulphur dioxide was run over the specimens for 3 minutes at 3 hour intervals, (3) a 2% solution of sulphur dioxide and (4) a normal (5.65%) solution of sodium chloride were run under similar conditions of alternate wetting and drying of the specimens.

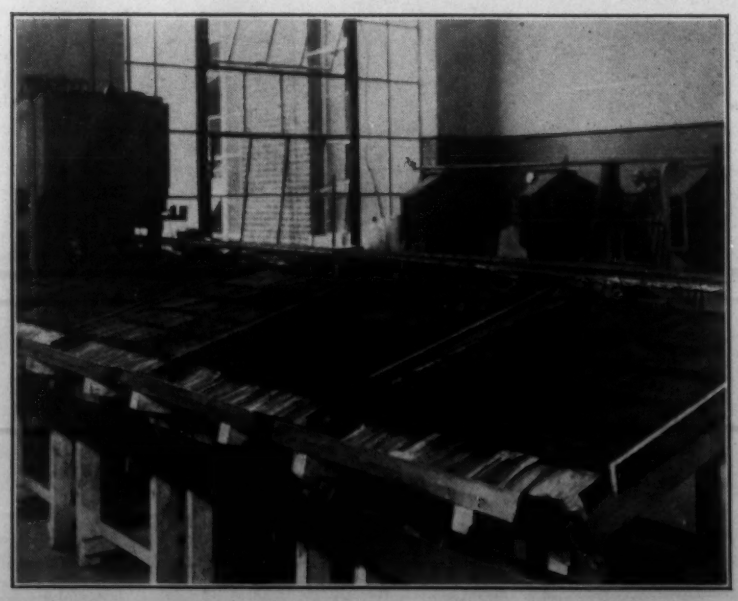


Fig. 4—First Series of Tests of Open Valley Flashings, Apparatus and Specimens

No definite indications of line corrosion were observed in any of these tests even after several weeks of testing.

During the first test, the water used became very strongly impregnated with materials leached out of the shingles. The effect, however, of this solution on the copper was hardly noticeable. Even at the end of the fourth test, no line corrosion could be observed, in spite of the fact that during all of this time the flashings were exposed to solutions which had run over and soaked through the wood shingles. This was believed to show that chemical action induced by wood shingles is not a factor of importance in the corrosion of valley flashings. It is evident that if this were true, failures of valley flashings would be far more common and not restricted to certain localities.

In the fifth test a mixture of 2% sulphur dioxide and 5.65% sodium chloride was used. Line corrosion began to be evident almost immediately. This test was continued until all of the specimens had failed. The number of cycles in this test required for each of the specimens to reach the failure point is given in Table I.

The fact that this solution produced very rapid line corrosion is believed to explain the fact that most of the known failures have been found in New York City and its environs, where the air is contaminated by coal smoke and also carries considerable "salt air." That no failures have been found in inland cities would then be explained by the very much slower rate of corrosion when sulphur dioxide alone is involved.

In order to make intercomparisons among the specimens complete penetration of the flashing at any point under the edge of the overlying roofing, where line corrosion would be expected to occur, was assumed to represent failure. In the case of specimens of Type III construction (Fig. 3), complete penetration of the upper layer of copper on the crimp was considered failure.

The test life of a specimen was taken as the number of cycles with the sulphur dioxide-sodium chloride solution required to cause failure.

A summary of the results is given in Table I, and shown graphically in Fig. 5. The test lives of specimens Nos. 4, 5 and 10 are

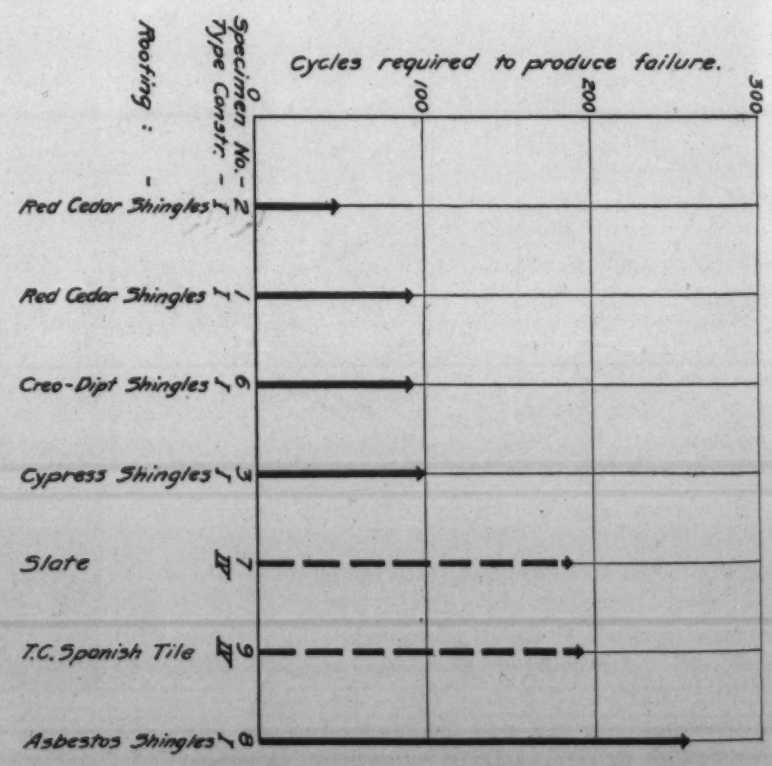


Fig. 5—Results of First Series of Tests of Open Valley Flashings. 16 Oz. Cornice Temper (Hard) Copper on Specimen No. 2; 16 Oz. Roofing Temper (Soft) Copper on All Other Specimens. The Broken Lines Indicate That the Roofing on These Specimens Was Separated from the Flashing by a Lath at the Edge of Which Line Corrosion Occurred

Fig. 6—Specimen No. 2 after Test. Arrows Point to Line Corrosion

not included in Fig. 5 as progress of corrosion was hidden by the overlying shingles.

The first failure occurred on specimen No. 2, which is shown in Fig. 6 in which the shingles have been removed and the lower (double) course has been separated and replaced a few inches above its original position. The line corrosion showed as a well-defined line (marked by the arrows) running across the specimen. All along the line was a deep groove and in addition, a number of holes at various points. At several places the line corrosion extended up along the sides of the shingles for an inch or more. The failure is typical of those which occurred on the other specimens.

Specimens Nos. 1 and 2 were similar in all respects save that soft copper (Roofing Temper) flashing was used on the first and hard (Cornice Temper) on the second. (Hard copper is practically never used for flashing purposes.) Specimen No. 2 failed after 50 applications of the mixed solution, while No. 1 required 93 applications for failure. Although results from tests employing only one specimen of a kind cannot be considered as entirely conclusive, yet they strongly indicated that no advantage would be gained by substituting hard for soft copper.

The test lives of specimens Nos. 1, 6 and 3 were practically the same. These specimens were covered with untreated red cedar shingles, "Creo-dipt" shingles, and untreated cypress shingles, respectively. No difference due to any variations of the chemical composition of the shingles was indicated.

Specimens Nos. 4 and 5 failed by line corrosion indicating that the special construction used on these specimens would not eliminate line corrosion.

On specimens Nos. 7 (slate) and 9 (Spanish tile), which were intended to be of Type I construction with the roofing touching the flashing, a lath was inserted under the lower course of roofing about 1″ back of the edge of the roofing. These specimens were accordingly listed as Type IV construction in Table I. Line corrosion appeared at the edge of the lath. The results do not represent true values for the Type I construction of these roofings, and, therefore, they are shown by broken lines in Fig. 5. One interesting feature was observed with regard to these specimens. Although the laths were wet during each cycle of the test, yet, since they were in close contact with the flashing, only small amounts of solution were held between laths and flashing. This seemed to account for the prolonged test lives of these 2 specimens. If this reasoning is correct, it should be possible to still further increase the life of the flashing by using a carefully finished strip of hard wood instead of a rough unfinished lath as was found for the same type of construction (Type IV) applied to wood shingle roofs in the second series of tests.

Specimen No. 8 with its roofing of heavy asbestos shingles or tiles showed a comparatively long test life.

Specimen No. 10 was covered with sheet copper shingles. These failed by corrosion before any line corrosion of the flashing could be detected. It should be noted that these shingles were of hard copper about one-half the thickness of the flashing, and that failure first occurred at bends and corners.

In Fig. 5 the specimens, reading from left to right, are arranged in order of increasing test life. It is significant that this is also the order of the specimens when arranged according to the rate of drying, from those drying most slowly on the left to those drying most rapidly on the right. Specimens Nos. 1, 2 and 6 dried very slowly, and at about the same rate. No. 3 dried noticeably faster, and Nos. 7, 8 and 9 quite rapidly. A relation between rate of drying and test life is suggested, but no definite conclusions could be based on the small number of specimens tested.

The results of the first series of tests were inconclusive in several respects. In particular, the 2 special forms of construction (Types II and III) did not prove to be immune to line corrosion. A second series was, therefore, undertaken.

Sketches showing a typical specimen are given in Fig. 7. The flashing was nailed to the supporting stand. A glass window under the flashing made it possible to detect the first penetration of the flashing. This assembly was arranged so that the roofing could be removed for inspection of the flashing and then replaced in its original position.

A descriptive list of the specimens used in the second series of tests is given in Table II. The general arrangement of the apparatus for distributing the corrosive solution to the specimens was the same as in the first series. About $^1/_{10}$ gallon of solution was required to thoroughly wet a specimen. The flow was adjusted to give approximately this amount in 6 minutes.

The same corrosive solution as that used in the final (5th) test of the first series (about 5.85% of sodium chloride and 2% of sulphur dioxide) was used. It was intended to run 6 three-hour cycles each night but this did not always allow the specimens to dry out thoroughly, especially during rainy weather when the humidity was high. Therefore, the schedule was varied at times to suit circumstances. Specimens and apparatus were cleaned at intervals as seemed necessary.

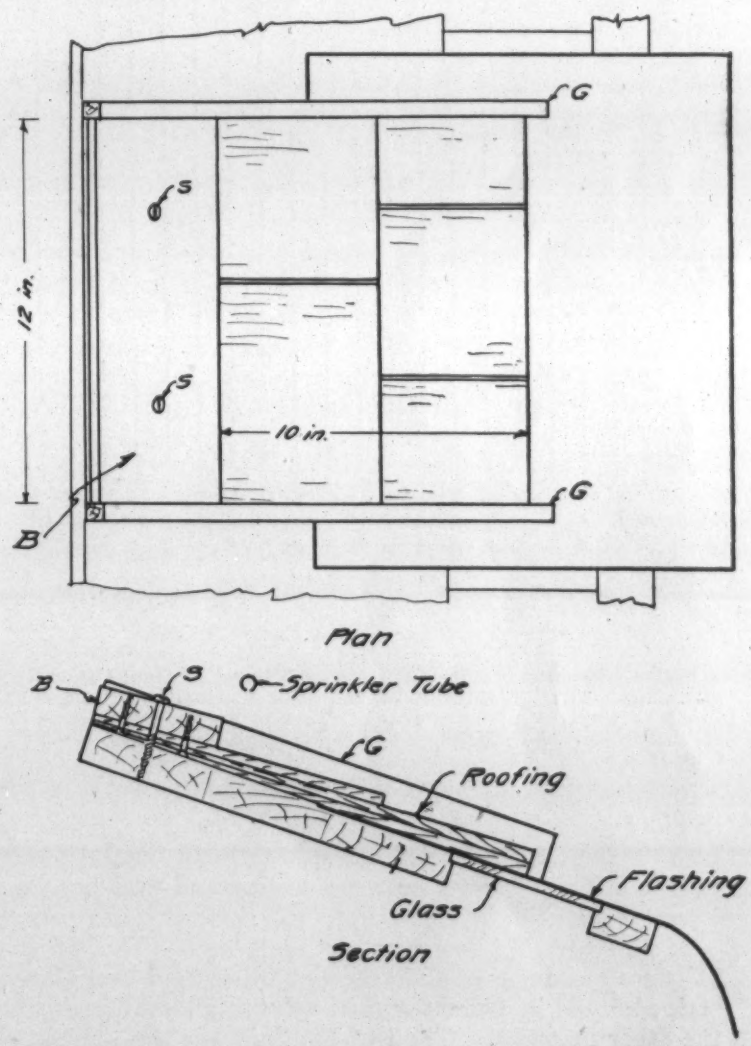


Fig. 7—Specimens for Second Series of Tests of Open Valley Flashings. The Roofing Is Fastened to the Block B and the Side Guards G. This Assembly Is Held in Place by the Removable Screws S

A résumé of the results of this series of tests is given in Table II and the comparative test lives of the specimens are shown graphically in Fig. 8. It is of special interest to note that specimens Nos. 27 to 30, inclusive, showed no signs of line corrosion at the completion of the test. Although specimen No. 13 had not failed at the end of the test, pitting had progressed almost through the flashing at one point so that failure was imminent.

The action of different roofing materials is well shown by comparing specimens No. 11 (wood shingles), No. 19 (composition shingles), and No. 20 (slate), all of Type I construction. All of these failed by line corrosion, and as nearly as could be judged by inspection, the total amount of corrosion was about the same in each case. However, the slate specimen (No. 20) which had the least porous or absorbent roofing and, therefore, dried out

Table II—Descriptive List of Specimens and Summary of Results of Second Series of Tests

Spec. No.	Type[a] Const.	Pitch	Roofing Material	Remarks	Line Corrosion No. of Cycles to 1st Trace	Failure	Remarks
11	I	1:3	Red Cedar shingles	.....	22	138	Severe line corrosion, one crack
12	I	1:2	" " "	.....	22	220	" " " , several cracks
13	I	2:3	" " "	.....	22	272	Line corrosion, several small holes
14	I	1:1	" " "	.....	71	148	Slight line corrosion, patch of severe corrosion with several holes
15	I	1:3	" " "	For continuous drip	...	...	Failed after 1152 hours of continuous drip
16	I	1:3	" " "	Heater, for rapid drying	22	138	Severe line corrosion, several holes
17	I	1:3	" " "	Flashing painted under shingles	31	242	" " " , one small hole
18	I	1:3	" " "	Roofing paper between flashing and shingles	31	220	" " " , one crack
19	I	1:3	Composition shingles	.....	31	158	Slight " " , one hole
20	I	1:3	Slate	.....	22	287	Line corrosion, several holes
21	II	1:3	Red Cedar shingles	.....	242	401	" " " "
22	II	1:3	" " "	Flashing painted under shingles	242	401	Severe line corrosion, several holes
23	II	1:1	" " "	.....	401	...	No failure at end of test, 475 cycles. Small patch deeply pitted
24	III	1:3	" " "	.....	138	242	Deeply pitted, hole through 1st layer of flashing
25	III	1:3	" " "	Flashing painted under shingles	242	373	" " " " " " " "
26	III	1:1	" " "	.....	...	242	Pitted, hole through 1st layer of flashing
27	IV	1:3	" " "	.....	...	...	No trace of line corrosion at end of test, 475 cycles
28	IV	1:3	" " "	Flashing painted under shingles	...	...	" " " " " " " " " "
29	IV	1:3	" " "	Batten strip waterproofed	...	...	" " " " " " " " " "
30	IV	1:1	" " "	.....	...	...	" " " " " " " " " "

[a] See Figure 3.

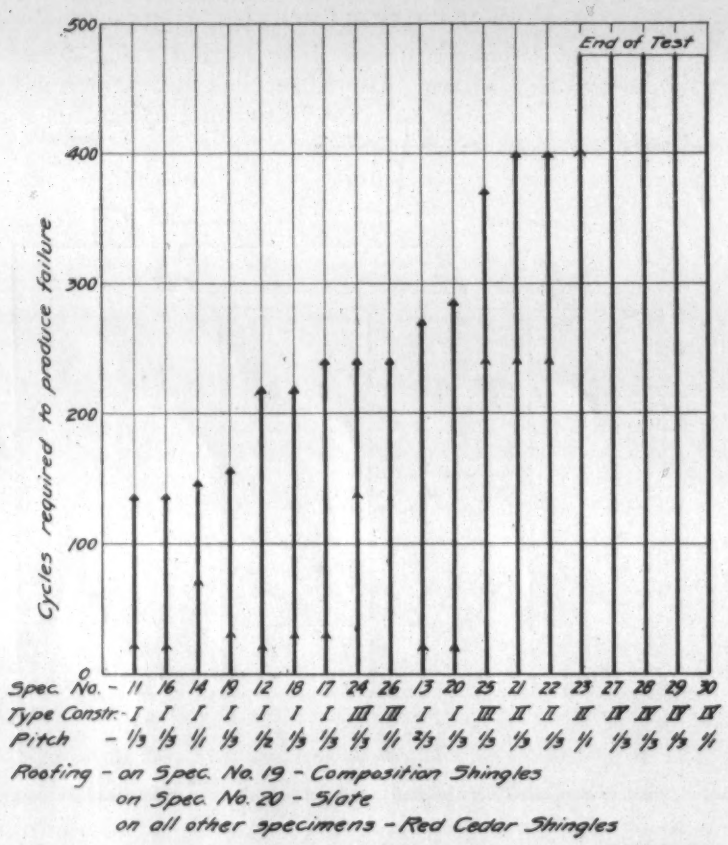

End of Test
Cycles required to produce failure
500
400
300
200
100
0
Spec. No. - 11 16 14 19 12 18 17 24 26 13 20 25 21 22 23 27 28 29 30
Type Constr. - I I I I I I I III III I I III II II II IV IV IV IV
Pitch - 1/3 1/3 1/1 1/3 1/2 1/3 1/3 1/3 1/1 3/3 1/3 1/3 1/3 1/3 1/1 1/3 1/3 1/3 1/1
Roofing - on Spec. No. 19 - Composition Shingles
on Spec. No. 20 - Slate
on all other specimens - Red Cedar Shingles

Fig. 8—Results of Second Series of Tests of Open Valley Flashings. First (Light) Arrowhead Represents First Noticed Trace of Line Corrosion. Second (Heavy) Arrowhead Represents Failure. All Flashings of 16 Oz. Roofing Temper (Soft) Copper

most rapidly in each cycle, had the longest test life. The composition shingles (No. 19) dried out more slowly than the slate, thus holding a film of water between roofing and flashings for a longer period each time. The failure was correspondingly hastened and the test life considerably shortened. The shingles (No. 11) were quite porous and absorbent, dried out very slowly, and retained liquid in contact with the flashing for a longer time than the other materials. The test life here was the shortest of all.

The effect of the roofing material as regards line corrosion appeared to be almost entirely dependent on the length of time which the material could hold solution in contact with the flashing. The more porous and absorbent the material, the shorter was the test life of the specimen.

It was concluded, on the basis of the results of both series of tests, that wood shingles are not the primary cause of line corrosion, that practically the only influence of the roofing material on line corrosion depends on its ability to retain water in contact with the flashing. This conclusion was borne out by the data relating to failures of valley flashings. These data show that line corrosion may occur in the absence of any material other than the copper itself. Moreover, failures appear to be restricted to certain localities. They do not occur generally in all places where wood shingles are used.

If this conclusion is correct, a specimen mounted on a steep pitch should have a longer test life because of the more rapid run off of water than a similar specimen with only a slight pitch. In general the test data showed this to be true.

An attempt was made to determine the effect of rapid drying by heating but the data were inconclusive.

Three possible methods of counteracting line corrosion were studied. These were painting of the flashing, separation of flashing and roofing by building paper and variations in construction.

The flashing on one specimen of each type of construction was painted with a heavy coat of red lead paint. The painting covered all of the flashing under the roofing and extended about one-half inch beyond the edges of the roofing.

The painting apparently had some retarding effect, but apparently not enough to recommend its use as a protective agent.

A sheet of building paper between shingles and flashing also increased the test life, but not enough to make the expedient of any great value.

A number of intercomparisons are possible for the 4 types of construction tested (see Fig. 3). Taking first the specimens Nos. 11, 21, 24 and 27, all with wood shingle roofing on 1–3 slope, it was found that in order of increasing test life the types of construction are I, III, II, IV. Taking next the specimens with painted flashings (No. 17, No. 22, No. 25 and No. 28) the same order is found. Finally for the set of specimens on a steep slope (1 to 1 pitch, specimens Nos. 14, 23, 26 and 30) the types of construction again rank in the same order.

The usual form of construction (Type I) thus appears to be the most susceptible to line corrosion. Type III construction, with a crimp in the copper which supports and raises the lower course of roofing, is considered a distinct improvement, though apparently much inferior to the remaining two types.

While it does not offer complete protection, the Type II construction is believed to have certain advantages which may make its use desirable with non-absorbent roofings like slate or under conditions of service not highly conducive to line corrosion. The flashing may be secured by cleats as is the usual practice, the batten strips may be placed by the carpenter before the sheet metal man starts his work. Finally, there is no obstruction to the flow of any water which might seep through the shingles just above the batten strip. Also, it might be added that any strips of wood of the right dimensions, such as laths, may be used as batten strips without special preparation. Since sharp bends are undesirable, the proper laying of the flashing is important.

None of the specimens (Nos. 27 to 30 inclusive) of Type IV construction showed any signs of line corrosion at the end of the test. This type of construction then should prevent line corrosion, or at least retard it to such an extent as not to limit the useful life of the roof. The value of this form of construction is stated to be dependent on 3 considerations. First, only a very small fraction of the water falling on the roof can ever reach the junction between the batten strip and the flashing. Second, the batten strip is in close contact with the flashing and, therefore, little if any water can penetrate between the strip and the flashing. And third, if the strip is of hard dense wood or is thoroughly waterproofed and has smooth surfaces, it will not hold water by capillarity to any appreciable extent. The strip then tends to prevent the formation of a slowly drying film of water such as causes line corrosion.

In the absence of data to the contrary, the author believes that the life of a flashing under actual service conditions on a roof will be directly proportional to its test life. The line corrosion produced by 138 test cycles on specimen No. 1, Type I construction, was about the same in amount as that which is produced in 15 years or more on a roof under the most severe conditions. Therefore if Type IV construction, which was unaffected by 475 cycles, were used on a roof, the flashing would probably show no signs of line corrosion for 50 years or more.

The probable cause of the line corrosion is discussed and is believed to be due to the setting up of oxygen concentration cells at the edge of the shingles where water is retained for considerable periods and is the last portion to dry.

It is concluded that:

1. Line corrosion of valley flashings can be reproduced by accelerated corrosion tests.
2. Wood shingles are not the primary cause of line corrosion.
3. Line corrosion may occur not only with wood shingles but also with slate, asbestos shingles, composition shingles, and under exceptional circumstances even when one sheet of copper overlaps another.
4. A solution containing a mixture of sulphur dioxide and sodium chloride produces line corrosion far more rapidly than solutions of either substance alone.
5. The rate at which line corrosion proceeds depends on the solution and on the time during which the solution remains without motion in contact with the flashing.
6. The length of time for which the solution remains in contact with the flashing after a rainfall depends on the porosity of the roofing. Hence, the more porous and absorbent the roofing material, the more rapid will be the corrosion.
7. On all open valley flashing, particularly in cities near the sea-coast where line corrosion may be expected, a batten strip should be inserted between the flashing and the roofing. This batten strip should be a smoothly finished hard wood strip, preferably waterproofed, having the approximate dimensions of a lath. It should be placed about one inch back of the edge of the roofing and nailed firmly and tightly to the flashing. There is reason to believe that, if this precaution is followed, no perceptible line corrosion will occur in 50 years or more of service on a roof under the severe conditions such as are found in New York City and its environs.—J. R. Freeman, Jr.

Monel Metal Castings

By Fred M. Chambers*

Making sound and ductile monel metal castings is generally considered to be a difficult task. However, if the patterns are well designed so that the section is not too irregular and strains are not set up in the casting, if the gating is properly done, and the metal properly scavenged, good castings can be made.

Specimens of monel castings are shown in Fig. 1. These castings were made in the Harrison plant of the Worthington Pump and Machinery Corporation, in green sand, without feeding heads. The sand was No. 0 Albany, with 6% moisture, rammed as for red brass.

Dry sand is not required for castings under 300-lbs. weight, and a 15-lbs. head will feed a 250-lbs. casting. In Fig. 1, casting No. 1 was made 4 in a flask, No. 2, 6 in a flask, and No. 3, 8 in a flask. The Brinelled face of No. 3 is the cope side. The gating for these was identical with that used in bronze.

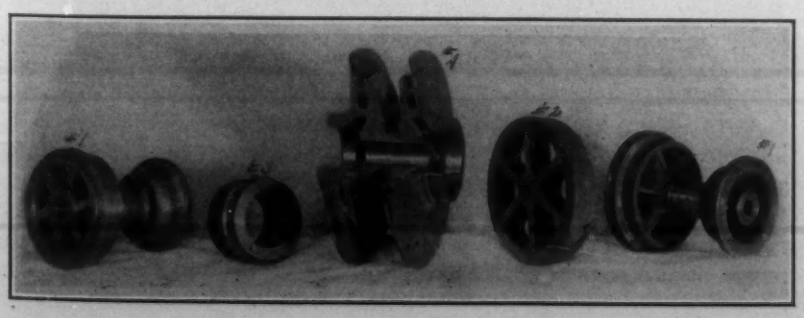


Fig. 1—Monel Metal Castings

On No. 4, Fig. 1, which is made one in a flask, and which, in bronze is gated from the top with four pencil gates, an extra drag was made, and the whole mold rolled over so as to pour from the bottom. This precaution is advisable in order to prevent small shot forming from division of the metal stream during top pouring. The shot do not melt in, and leave pits in the casting after machining.

Bottom gating on flat surfaces is shown in Fig. 2, which also shows that large heads are not used.

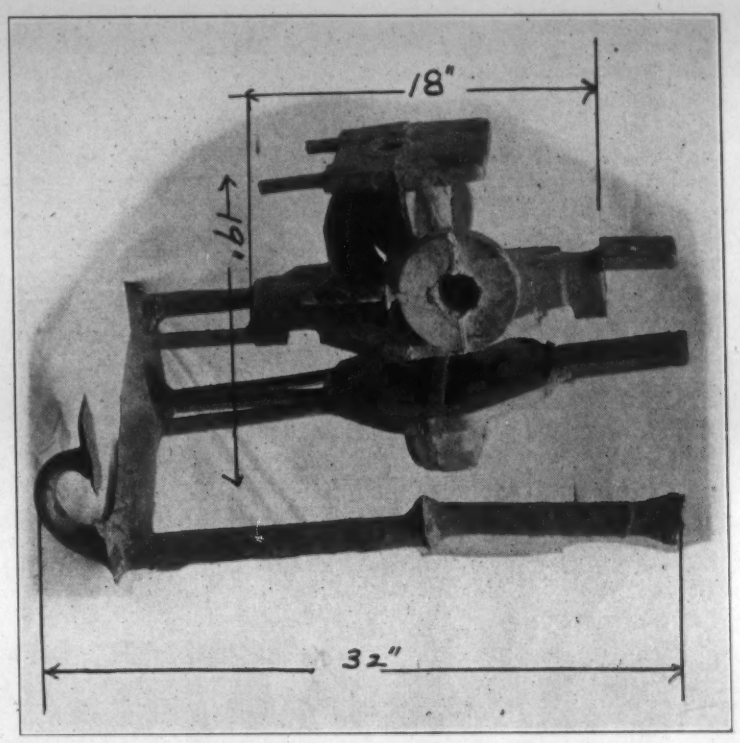


Fig. 2—Monel Metal Green Sand

Given a properly designed pattern and a properly gated mold, the main trick in producing good monel castings is in melting the metal and scavenging it. Monel is, of course, like any nickel alloy, sensitive to the presence of sulphur. The castings shown were poured from metal melted in an oil-fired crucible, using fuel oil with $^3/_4$ of 1% of sulphur. No covering, such as glass, etc., was used on the metal. Higher sulphur fuel will give up enough sulphur to the metal to produce a flinty, open grained and entirely useless casting. The metal should be gotten hot.

The 200-lb. charge used consists of scrap monel rod ends, drop-forging blanks and sheet clippings, and is so bulky that only 30 lbs. can be charged at the start, the balance being added through the hole in the furnace cover as melting progresses. The heat takes about $1^3/_4$ hours. To very hot metal while still in the furnace, 3 lbs. of ferro silicon (80% Si) is added, and stirred in with an iron rod. After the crucible is drawn, 5 ozs. magnesium is plunged to the bottom of the crucible with a pair of long nosed tongs.

The metal is not only melted hot, but is poured hot immediately after making the magnesium addition.

With these precautions, good monel castings can be consistently produced.

Calendar of Meetings

International Exposition at Liége, Belgium, Chemical and Engineering Session, Sept. 14–21.

Société dé Chimie Industrielle, Liége, Belgium, Sept. 21–27.

National Metal Congress and Exposition, Hotel Stevens, Chicago, Ill., Sept. 22–27.

American Society for Steel Treating, Annual Convention, Chicago, Ill., Sept. 22–27.

Institute of Metals Division of American Institute of Mining and Metallurgical Engineers, Annual Fall Meeting, Chicago, Ill., Sept. 22–27.

Iron and Steel Division of American Institute of Mining and Metallurgical Engineers, Annual Fall Meeting, Chicago, Ill., Sept. 22–27.

Iron and Steel Division, Machine Shop Practice Division American Society of Mechanical Engineers, Annual Fall Meeting, Chicago, Ill., Sept. 22–27.

American Welding Society, Annual Fall Meeting, Congress Hotel, Chicago, Ill., Sept. 22–27.

British Cast Iron Research Association, London, England, Oct. 29.

American Gas Association, Atlantic City, N. J., Oct. 13–17.

Association for the Advancement of Science, Cleveland, Ohio, Dec. 29–Jan. 31, 1931.

* Woodbury, N J.

Correlated Abstract

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts reviewing the work recently reported pertaining to certain subjects. These reviews will take into consideration the work of a number of workers.

Production of High Test Cast Iron

Development and Present Status in the Light of Foreign Advances

By Dr. G. Neuendorff

In this review, the historical development of the production, as well as the investigations, which had the greatest influence on the practical development of high test cast iron, will be outlined. The more recent practical developments will also be considered, but no conclusions will be drawn, as in most cases, the time has been too short to pass judgment. Nevertheless, it can be stated at this time that the various methods do not have equal merit and some of the new methods will prove short-lived.

For unknown reasons the metallurgy of cast iron has been sadly neglected, these may have been in part psychological, in as much as steel was always considered a better material. Scientific research in the last ten years, has discovered so many new facts about cast iron that the production of high grade cast iron has made remarkable progress.

In this survey the subject will be considered under the following three divisions:

1. Improvement by a favorable crystallization of the pearlitic ground-mass.

2. Improvement by decreasing the amount of graphite as well as a refining of the graphite crystallization.

3. Improvement by the addition of alloying elements.

Special reference will be made to German achievements,[1] as the German literature is not so readily available nor so easily read, even if available, as the American and English. The European foundryman devoted his researches more to the first two divisions while improvement by the addition of alloying elements received its greatest impetus in the United States. The latter division will, therefore, receive scant consideration.

Si. 3.50
Ratio = Cubic Inches Contents ÷ Square Inches Cooling Surface
Breadth of Test-Bars
Si. 2.50
Si. 2.00
Si. 1.50
Si. 1.00
Load for Test Bars of 1 inch Square
Multiplier to give Maximum
Strength of a 1" Square section 12" long in lbs.

Reproduced from Keep-Cast Iron. John Wiley & Sons Inc

Fig. 1

When Keep[2] published his investigations in 1898 on the influence of silicon on iron castings with variable wall-thickness, the most important factor of the relation between structure and velocity of crystallization and cooling was made known. From the diagram in Fig. 1 we observe that for each composition there is a most favorable wall-thickness (velocity of cooling). Furthermore, it is evident that variations of the physical properties with the wall-thickness decrease with lower silicon content, in other words, low silicon cast iron is less sensible to the cooling rate than high silicon iron. In part, these results are due to decreasing graphite crystallization with decreasing silicon content and proves that the structure with the highest physical properties largely depends on the carbon and silicon content.

In 1906, Goerens[3] in comparing the structures of steel and cast iron pointed out that cast iron, which he considered as steel with imbedded graphite, should have its best physical properties with a pearlitic crystallization. The efforts of foundrymen to improve cast iron can be dated back to this time. Another decade passed before the first practical results were obtained along the lines laid down by Goerens, by Diefenthäler and Sipp.[4]

Cast iron, produced according to the Diefenthäler[5] patent is generally known as Lanz-Pearlitic Iron. To obtain a pearlitic ground mass, the silicon content as compared with Keep's investigations was, for certain purposes, decreased further to about 0.6%. On the other hand, the cooling velocity is closely regulated. The control of cooling velocity is accomplished by heating the sand molds to the necessary temperature to accomplish the cooling rate for a pearlitic crystallization. Silicon and carbon contents for various sections are as follows:

Medium-	C + Si = approx. 4% (with C ≦ 3.5%, Si ≦ 1.5%)
Heavy-	C + Si = 3.4% (C ≦ 2.9%, Si ≦ 0.9%)
Very thin-	C + Si = 4.6% (C ≦ 3.5%, Si ≦ 1.2%)

The process was patented in 1916 and applies two means to obtain a pearlitic structure: First—a carefully selected composition varying with the cross-section of the casting; Second—heating the sand molds to obtain a suitable cooling rate.

Bauer[6] reported on a comparison of an ordinary cast iron (G), a so-called cylinder cast iron (Z), and a pearlitic iron (P), giving the results of investigations on structure and physical properties. The curves in Fig. 2 show an improvement of all physical properties, and the increase in toughness upon alternating impact tests, should be pointed out especially. Among the valuable properties of pearlitic iron, the pronounced resistance to abrasion and the large stability of volume[7] at higher temperature are most essential and open up many new fields for this material. The results of fatigue tests with various cast irons published by Moore and Lyon[8] are very interesting.

At almost the same time the importance of graphite crystallization was emphasized. At present the influence of a finely divided distribution of graphite on the physical properties is thought to be more pronounced than a pearlitic ground mass. Bardenheuer and Zeyen[9] in their report on cast iron stated, "The importance of the graphite shape on the strength of cast iron seemed to be neglected for a time, in favor of the pearlitic ground mass, as a result of the papers of Sipp[4] and Bauer.[6] In the discussion of a paper by Sipp, though, Stotz pointed out that the tensile strengths of 25–30 kg./mm.² (35, 500–42, 600 lbs./in.²) and the favorable impact values of pearlite iron were, in his opinion, not due to the pearlite content but to the low C, P and S. The low carbon content should be given as the reason for the finely divided graphite crystallization. Maurer,[14] on the other hand, in his

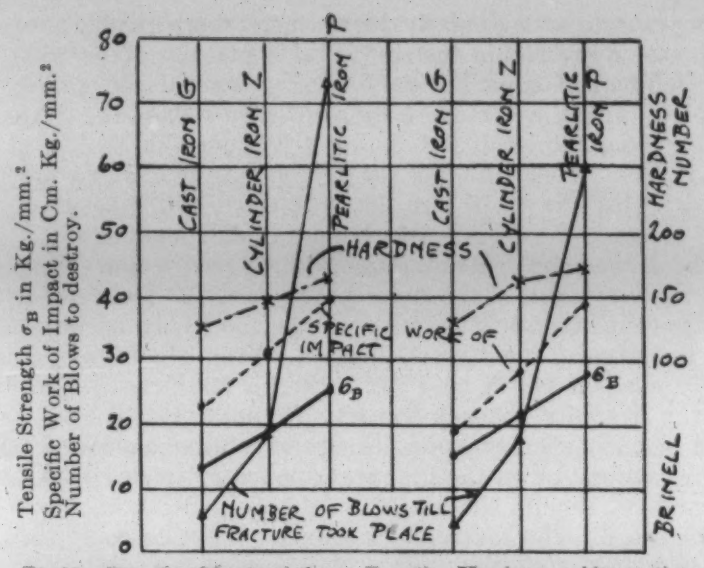


Fig. 2—Results Obtained from Tensile, Hardness, Alternating Impact and Impact Transverse Tests

Table 1—Analysis of Average Samples (Fig. 2)

	Total Carbon, %	Graphite, %	Combined Carbon, %	Silicon, %	Manganese, %	Phosphorus, %	Sulphur, %
Cast Iron "G".....	3.29	2.99	0.30	2.79	0.56	1.15	0.084
"Cylinder" Iron "Z"	3.51	2.84	0.67	1.74	0.66	0.50	0.076
Pearlitic Iron "P"..	3.25	2.41	0.84	1.11	0.79	0.40	0.154

first report on the cast iron diagram emphasizes the importance of the pearlitic ground mass.

Bardenheuer and Zeyen[9] carried on investigations to determine whether the shape of the graphite crystallization or of the pearlitic ground mass has a greater influence on the improvement of cast iron. In examining three different melts of cylinder-iron (1.7–1.9% Si, 0.6–0.8% Mn, 0.3–0.5% P, 0.06–0.1 S) and two irons with low phosphorus and sulphur content with 1.6–1.9% Si, 0.8–1.0% Mn and 3.5% Si, 0.6% Mn, respectively, they found that the melts cast in iron molds would always show better physical properties after annealing than those cast in sand. They, therefore, drew the conclusion that the ground-mass structure at first has a subordinate bearing on the physical properties. The shape and distribution of the graphite have a predominating influence on the physical properties. In the annealed chilled iron the graphite distribution is much finer than in the sand cast. The authors state further that, if the coarse graphite crystallization is avoided, improvements in physical properties can be obtained by influencing the pearlitic ground mass.

Many papers, which on the one hand emphasize especially the necessity of diminishing the amount of graphite and on the other point out the importance of a finer graphite distribution within the pearlitic ground mass, have appeared in recent years. As early as 1903, Wüst[10] called attention to the fact that cast iron with a lower carbon content has more favorable physical properties, as a result of a finer graphite distribution, whereas, cast iron with a higher carbon content shows a coarse graphite crystallization. He stated that it was possible to produce cast iron with less than 3% carbon in a cupola with a fore-hearth. In 1904 Leyde[11] remarked that the strength of cast iron is influenced more by the kind and size of the graphite than by the quantity of the graphite itself.

These two investigations emphasize the viewpoints to be taken into consideration in improving cast iron by a suitable control of the size and quantity of graphite. Many investigations along these lines, which confirmed the correctness of these ideas, were carried on in recent years. Since it is impossible to cite all the literature, only the most important will be referred to.

Wüst and Kettenbach[12] investigated the relation between the physical properties of gray cast iron and graphite content holding the silicon constant. In all the four series investigated: 1. 0.8–1.0% Si; 2. 1.1–1.4% Si; 3. 1.5–1.9% Si; and 4. 2.1–2.4% Si, it was found that the highest properties are obtained with the lower carbon contents. Bending strength, tensile strength and hardness generally decrease with increasing graphite content. It is of interest to note that the statement is made in this publication that the test bars with exceptionally high physical properties showed the graphite crystallized in the form of temper carbon. Ten years later this observation was rediscovered. Doubtless the scientific basis for the production of high test cast iron was known before the war, but the problem had not been solved satisfactorily, practically.

Emmel[13] deserves credit in developing the Thyssen-Emmel process for making the cupola the instrument for the improvement. Emmel attains a low carbon content, below 3%, in the regular cupola process by controlling the carburization of the cast iron by enlarging the melting zone by arranging a double system of tuyéres in the cupola. Before Emmel invented his process, it was only possible to produce a low carbon cast iron in the reverberatory or electric furnace. He easily obtains a high test cast iron with 2.5–2.8% carbon without any subsequent treatment.

The low carbon content precludes a lower graphite content and the lower content of graphite results at the same time in a finer distribution. With reference to the lower carbon content, the silicon content must be increased to bring about a sufficient segregation of graphite. The silicon content of the Thyssen-Emmel cast iron, therefore, ranges from 2.0–2.7%. Emmel recommends that the carbon and silicon contents total about 5%. Tables 2 and 3 give some of the results.

Table 2

Analysis C	Si	Mn	P	S	Tensile Strength lbs./in.²	Diameter of Test Bar in.
2.48	2.31	1.07	0.18	0.164	42,500–45,500	0.79
2.32	2.82	1.04	0.25	0.106	45,000–47,000	0.79
2.60	3.29	1.33	0.10	0.104	44,000–45,500	0.79
2.85	2.35	1.02	0.14	0.105	47,500–48,500	0.79

Table 3

Diameter of Test Bar, Mm.	Surface of Test Bar	Length, in.	Bending Strength, lbs./in.²	Deflection, in.
15	Not machined	11.8	90,500–104,500	0.19–.16
18	Machined	11.8	92,000–105,500	0.34–.24
30	Not machined	23.6	86,000–96 ,500	0.43–.39
30	Machined	23.6	85,500–102,000	0.59–.39
30	Machined	28.3	92,000– 94,500	0.69–.66
	Brinell Hardness	210–240		

The results, obtained by the Krupp Company with the so-called "Sternguss" were similar. In varying the total of the silicon and carbon content to suit the kind of castings made and in melting an iron with a low carbon content, the best results were obtained. The Krupp "Sternguss" is derived from the Maurer diagram[14] for cast iron, and with the analysis given by Kleiber[15] (C. 2.4–2.7%; Si. 1.66–2.33%; Mn. 0.86–1.48%; P. 0.1–0.2%; S. 0.08–0.13%) has a bending strength of 61 kg./mm.² (86,620 lbs./in.²). Along the same line may be mentioned the tests of Smith[16] and the cast iron Mechanite as produced by the Ross-Mechan foundries in Chattanooga, Tenn.[17] Mechanite is especially distinguished by its high stability of volume at higher temperatures.

A cast iron with a low carbon is also produced by the Corsalli method.[18] For a time the idea was held that it should be possible to produce a low carbon cast iron in the cupola by charging up to 90% steel scrap. After Ledebur's and later Klingenstein's[19] thorough investigations, this idea had to be discarded. Even using wrought iron, Klingenstein could not come below 3.1–3.2% carbon content. Even then, in using a low carbon raw material, difficulties result from the low melting rate. By forcing the cupola, these difficulties can be eliminated but then the foundryman runs the chance of a greater loss of manganese and silicon. Corsalli developed his process, based on these facts. He melts a cast iron of 2.70–3.00% carbon, using 60–70% steel scrap and blowing with $1^1/_2$–2 times the air volume. The object of excess blast is to obtain direct refining; the absorption of carbon from the coke is thereby retarded if not prevented. To overcome burning out manganese and silicon, these two materials are added covered with a skin or shell of iron. Later, these materials were introduced into the cupola from the outside at the level of the melting zone. This part of the charge was melted in a special device by the cupola waste gases, i. e., poured in molten. Corsalli furthermore suggests the application of low reactivity coke. Gilles, in his investigations, therefore, used a coke which had been dipped in lime-water. This treatment, it is claimed, brings the coke down into the melting zone unburned. Some of the results of the tests of Gilles are given in Table 4.

Special attention is called to the investigations, which seek to manufacture high test cast iron by systematically influencing the graphite crystallization, which is most successfully accomplished by superheating.

However, before summarizing the valuable results brought about by superheating cast iron, which is successfully applied in practice, a brief résumé of previous investigations will be given. Piwowarsky, Bardenheuer[20] and Zeyen[21] pointed out that the desirable goal of the foundryman was a eutectic graphite crys-

Table 4—Physical Properties of Cupola Cast Iron Made by the Corsalli Process (Gilles)

Test No.	Total C, %	Graphite, %	Combined C, %	Si, %	Mn, %	P, %	S, %	30 mm. Rod Rough Cross Bending K_b	20 mm. Rod Machined K_z
4	2.98	2.06	0.92	1.62	0.86	0.29	0.138	58.9	12.4	34.2
5	2.95	2.00	0.95	1.57	0.78	0.28	0.132	56.1	10.0	36.1
6	2.90	1.98	0.92	1.53	0.83	0.29	0.134	54.9	10.0	38.0
7	2.94	1.98	0.96	2.09	1.07	0.22	0.111	53.5	10.4	34.8
8	2.77	1.94	0.83	2.00	0.89	0.25	0.137	56.1	10.4	38.8
9	3.00	1.86	1.14	2.03	1.19	0.27	0.146	62.5	10.0	39.5
10	2.88	0.92	0.92	2.20	0.75	0.21	0.185	56.5	11.8	35.6
11	2.77	0.82	0.82	2.06	0.74	0.25	0.165	52.4	9.4	37.1
12	2.90	0.89	0.89	2.09	0.99	0.26	0.107	52.6	9.8	34.8

tallization. As late as 1922 Schüz[22] wrote, "It is of considerable practical interest to know by what means a eutectic graphite crystallization can be obtained." The latter gave special attention to the graphite eutectic.[23] In high silicon castings (over 3%) he was successful in crystallizing the largest share of the uncombined carbon present as eutectic. This graphite eutectic could be reproduced without difficulty. The most essential requirement was to avoid too slow a cooling rate. Schüz poured his test bars into iron molds. The resulting thin chill had to be eliminated by a subsequent short heating to about 800–850° C.

Tensile strengths up to 30 kg./mm.² (42,600 lbs./in.²) and bending strengths up to 85 kg./mm.² (120,700 lbs./in.²) could be obtained. While Schüz's investigations are interesting, their practical value is questionable. The high silicon content and subsequent heat treatment add considerably to the manufacturing costs.

A new viewpoint is thrust into the discussion on graphite refining, by the investigations of Piwowarsky,[24] who by a preliminary superheating of the cast iron, accomplished an improved graphite crystallization and consequently better physical properties. This work was the beginning of a number of further investigations, which were carried out especially at the Kaiser Wilhelm Institut für Eisenforschung in Düsseldorf.

A review of the literature on the temperature influence, melting as well as casting, on the physical properties, shows a considerable divergence of opinion. Theoretically, a higher casting temperature should favor the formation of graphite, as a hotter iron heats the molds more, i. e., the cooling of the molds proceeds more slowly, thus favoring the graphite crystallization. The contrary, a pronounced decrease in graphite content, was noted by some authors; carbide formation was favored. Hailstone[25] observed a decrease in graphite content with an iron of the following composition: 3.24% T. C., 1.87% Si, 0.30% Mn, 1.4% P, 0.1% S, up to 1425° C., the highest temperature applied by him. Similar results were obtained by Honda and Murakami.[26] Northcott's[27] results contradicted the above.

Piwowarsky[24] in his early tests examined a Swedish charcoal iron (4.01% T. C., 0.063% Si, 0.13% Mn, 0.019% P, 0.075% S) and found the results shown in Table 5 and Figs. 3 and 4 on

Table 5—Results of Tests

Temp. ° C.	1153	1250	1475	1550	1600	1810	2010	2200	
Total C %	4.01	4.70	5.20	....	5.74	6.00	....	7.96	Series I
Combined C %	1.83	2.19	3.43	....	3.20	2.14	....	3.73	Series I
Total C %	4.01	4.60	4.30	4.25	4.20	3.80			Series II
Combined C %	1.22	1.28	2.43	1.28	1.15	0.73			Series II
Total C %	4.01	5.10	5.00	....	4.80				Series III
Combined C %	0.68	0.89	1.76	....	1.18				Series III

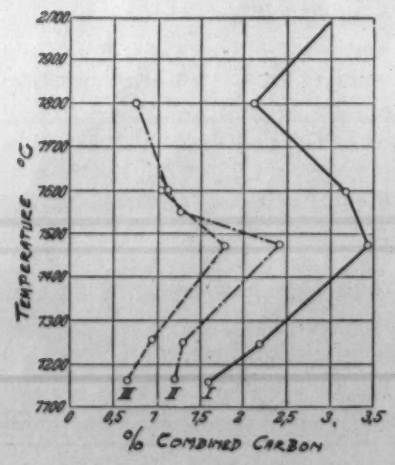


Fig. 3

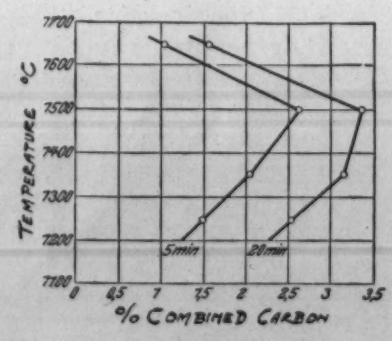


Fig. 4

superheating it. The curves show that up to a certain superheating temperature, the tendency to graphite segregation first decreases and than increases. The influence of increasing the time of superheat, acts similarly to an increasing temperature. In each case a reversal in the curves takes place at about 1500° C. The method of superheating not only lowered the amount of graphite within a certain range, but also refines the graphite, as may be observed in Fig. 5. As it is impossible to deal in detail in this review with the theoretical conclusions which Piwowarsky[28] has drawn, the reader is referred to his paper at the 1927 meeting of the American Foundrymen's Association.

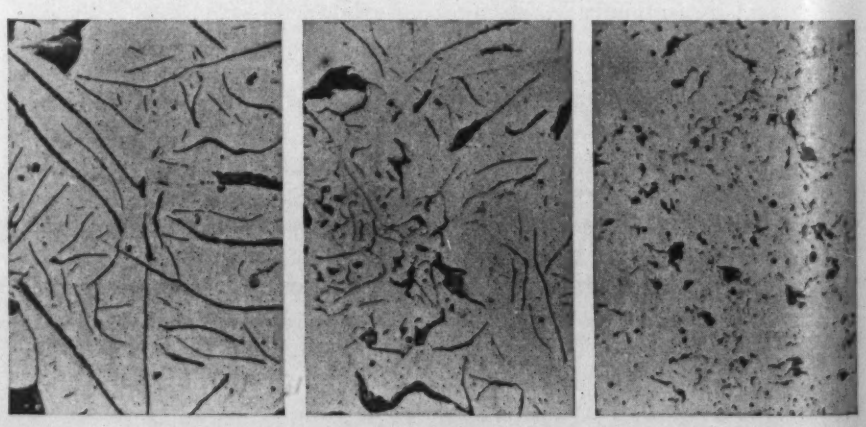
The Hanemann[29] investigations introduced a new viewpoint into the discussion of the superheating theory. He showed that undissolved graphite nuclei within the melt play an important role in the subsequent crystallization. From the tests of Sauerwald[30] carried out, in an effort to find a mathematical relation for the graphite solution velocity in unsaturated iron melts must be concluded, that the velocity of solution should be taken into consideration in the practical application of the superheating process, though the graphite solution depends more on the temperature. The course of Piwowarsky's curves could then be explained in the following way. The course of the curve up to the reversal point is characterized by the presence of undissolved graphite nuclei, which disappear more and more with increasing temperature and time of superheating. The conditions for the slope of the curve after the reversal point are given by the retarded cooling which favors the graphite segregation.

The Hanemann investigations resulted in the development of a practical method of producing high test cast iron. Instead of superheating at higher temperatures (1450–1650° C.) for a short time, he heats at lower temperatures (1350–1450° C.) for a longer period. The average results of a large number of air furnace heats having 3.14% C, 1.66% Si were:

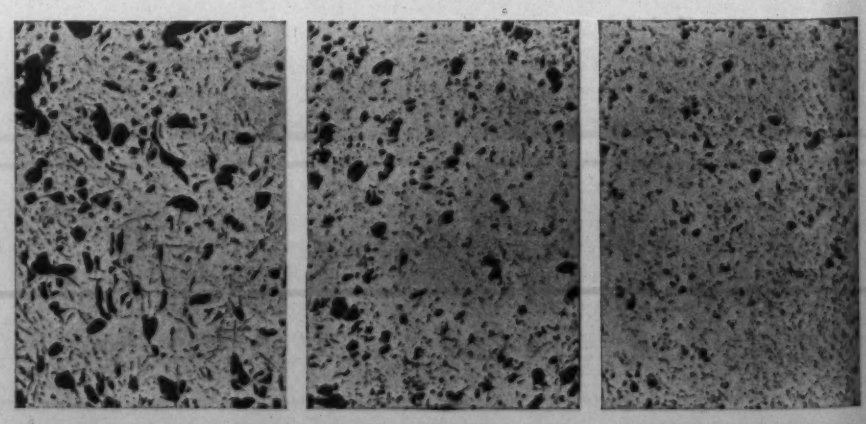
Tensile strength	30.3 kg./mm.²	(43,000 lbs./in.²)
Bending strength	48.0 kg./mm.²	(68,000 lbs./in.²)
Deflection	9.6 mm.	(0.37 in.)

In a recent publication, Bardenheuer and Zeyen[31] investigated the influence of superheating on different cast iron compositions. The principal conclusion resulting from this investigation was that the improvement of the physical properties depends in a large measure upon the carbon content. This fact doubtless stands to reason due to the given theoretical considerations. In these tests two irons with low P and S content and high P and S content were used. Each of these materials was produced with high carbon content (about 3.4%) as well as low carbon content (3.0% or less). Both materials were melted and superheated in

Melting Series I Unetched × 100



Melting Series II Unetched × 100



Heated to 1250° C. 1425° C. Poured at 1250° C. 1600° C.

Fig. 5—Influence of Temperature on the Formation of Graphite in High Carbon Cast Iron

a high frequency induction furnace. The superheating temperatures were:

Group A 1350–1380° C.
Group B 1460–1500° C.
Group C 1580–1630° C.

All bars were cast in dry sand and poured at 1350° C. Some of the results are given in Table 6. Melt No. 1 has the lower

Table 6

Melt No.	Superheat, Deg. C.	Bending Strength, lb./in.²	Deflection, in.	Tensile Strength, lb./in.²	Analysis, Percent C	Si	Mn
1	1365	58,700	0.57	33,400	3.44	1.10	0.87
	1480	65,300	0.61	34,400	3.34	1.21	0.88
	1605	67,500	0.38	40,900	2.79	1.82	1.05
2	1365	76,700	0.59	44,300	3.03	1.33	0.87
	1480	68,500	0.50	37,700	2.97	1.41	0.92
	1605	63,500	0.35	39,100	2.80	1.60	0.89
7	1365	82,500	0.45	40,900	2.59	2.28	0.93
	1480	73,000	0.35	43,000	2.57	2.29	0.97
	1605	70,500	0.36	46,600	2.61	2.28	1.01
10	1365	60,400	0.41	35,500	2.79	2.38	1.05
	1480	60,000	0.37	35,000	2.73	2.37	1.04
	1605	78,500	0.43	43,600	2.81	2.54	0.91
14	1365	57,100	0.28	39,400	2.52	3.85	0.94
	1480	60,600	0.35	39,200	2.54	3.84	0.96
	1605	72,500	0.35	38,200	2.57	3.72	0.93
18	1365	55,400	0.41	34,500	3.22	1.84	0.55
	1480	60,200	0.43	34,800	3.17	1.77	0.51
	1605	69,500	0.47	40,700	3.16	1.81	0.57

carbon content, whereas Nos. 2 and 7 represent melts with higher carbon content. In melt No. 10 half of the silicon was added in the ladle, Melt No. 14 has a high silicon content and Melt No. 18 contains 0.39% Cr. The following conclusions can be drawn from the results: Low carbon content melts show a decrease in physical properties, whereas melts with high carbon content show an essential improvement which is due to a fine graphite crystallization. Similar results were obtained in testing the samples with the higher phosphorus and sulphur content. The melts with 3.2% carbon and less showed a tendency to a dendritic crystallization. This explains the observed increase in bending strength. The dendritic crystallization did not influence the tensile strength, which increases in spite of the dendritic structure, probably as a result of the finely distributed graphite. An improvement in superheated cast iron with low carbon content can be obtained with a high silicon content, by adding part of the silicon in powdered form in the ladle, or by alloying with chromium.

Practice has fully confirmed the results of Piwowarsky, Hanemann, Bardenheuer and others and applied them to advantage.

An interesting arrangement for superheating is represented by the combination of cupola and oil-fired air furnace, the so-called "Wüst furnace" described by Klingenstein.[19] Some data on oil furnace melts, as reported by Klingenstein can be seen in Table 7.

Table 7

T. C.	Si	Mn	P	S	Tensile Strength lbs./in.²	Bending Strength lbs./in.²	Brinell Hardness
3.06	2.04	0.83	0.36	0.021	35,500	63,000	225
3.31	2.40	0.76	0.46	0.055	32,000	55,000	195
2.70	1.66	0.90	0.42	0.077	47,500	78,000	215
2.70	1.67	0.96	0.39	0.074	43,500	77,500	235

A method for diminishing and refining the graphite differing from the above, is the shaking and jolting method of Deschesne.[32] The method used a cupola forehearth, which is lifted by means of two trunnions about 100 times per minute. The improvement of cast iron by shaking is doubted by some metallurgists.[33] Also it has not been proven if the improvement results from a refining of the graphite or from desulphurization. From a few tests by Bardenheuer[9] on this subject, he concludes that the mechanical movement of the bath cannot be applied to standard cupola iron. He shook standard cupola iron in a ladle on a vibrating molding machine but could find no improvement. When Irresberger found an improvement, it must be ascribed to the high quantity of steel scrap used, up to 70%. On the other hand, the success with this high steel-scrap iron may be due to a better mixing of the melt by this shaking method.

The electric furnace is excellently suited for superheating. Kerpely[34] was successful in producing high test cast iron even with a high phosphorus content (C over 3%, P up to 0.8%) in the electric furnace. Table 8 gives some results. Kerpely in later papers[35] pointed out one fact, which deserves consideration and which doubtless points to a very important problem in iron founding, namely, slag reactions. Kerpely after a special slag treatment for a better deoxidization of the bath, obtained a

Table 8

C %	Si %	Mn %	P %	Tensile Strength lbs./in.²	
3.15	1.83	0.94	0.65	45,500	Scrap iron + 10% Steel scrap
3.10	1.73	0.85	0.80	50,000	
2.95	1.78	0.98	0.81	51,500	
3.12	1.83	0.93	0.77	53,500	
3.20	1.92	0.93	0.80	50,000	

pure temper-carbon like crystallization of graphite and a tensile strength over 40 kg./mm.² (56,800 lbs./in.²) with 3–4% elongation. The bending strength was 70 kg./mm.² (99,400 lbs./in.²) with a 30 mm. (1.18 in.) diameter test bar. Also Bardenheuer and Zeyen[9] pointed out that the best physical properties are obtained with a graphite crystallization, similar to the shape of temper carbon.

The most recent development on the operating side of cast iron improvement is the Brackelsberg furnace. In the first experiments carried on by Bardenheuer[36] at the Kaiser Wilhelm Institut für Eisenforschung, he especially investigated the metallurgy of this rotating furnace, fired with pulverized coal and clearly pointed out its advantages. Briefly considered they are: Melting is carried out very quickly, as the coldest parts of the charge are always subjected to the hottest flames. This quick melting down offers the advantage of a very limited oxidation of iron and alloying elements. The metal bath is continually covered with a layer of slag, which protects it from the influence of the furnace atmosphere. The temperature necessary for tapping can, therefore, be attained without the bath being saturated with gases and oxides. The practical elimination of gases and oxides seems to offer the explanation for the results of this furnace in producing a cast iron, with a dense structure, absolutely free from cavities, holes and pipes. Further, the cast iron produced in the Brackelsberg furnace is very fluid and consequently fills very well, even small cross-sections. Even with low carbon content, this cast iron possesses a high fluidity, which otherwise is only known with high carbon and phosphorus cast irons. The excellent pouring qualities may be due to a far-reaching sub-cooling, as can also be observed otherwise with alloys low in absorbed gases. The importance of gases on the crystallization of graphite has also been stated by other authors, as Kerpely and Hanemann.

In a later paper Bardenheuer and Zeyen[37] call attention to the heat economy of the Brackelsberg furnace (Fig. 6) and, in examining the materials and heat of two melts of malleable cast iron and one of gray cast iron, they state that in respect to heat efficiency, the Brackelsberg furnace is superior to all other melting methods. The principal results are briefly given here: Pulverized coal consumption (8.22% ash, 3.5% humidity) 9.67–14.32%; iron loss by oxidation, 0.65–1.96%; thermal efficiency 28.70–40.74%; exhaust gas losses 45.05–55.36%.

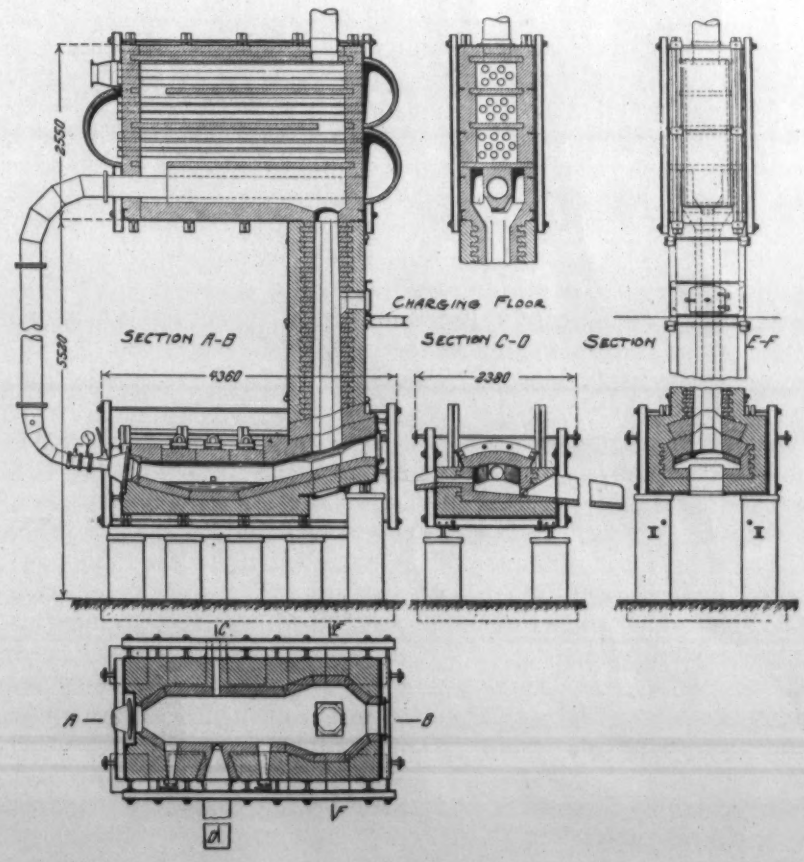


Fig. 6

The losses due to incomplete combustion of the fuel are relatively small and can be decreased to less than 5%. It can be said that the thermal efficiency of the Brackelsberg furnace compared with other types of melting furnaces is much more favorable for cast iron. The thermal efficiency can be further improved by using the waste gases to heat the combustion air, this will cut down the melting time, and improve the fuel consumption. The furnace is built for a normal capacity of 4–5 tons and its practical application has met with great success.

The European views, on the improvement of gray cast iron by the addition of special elements, are that in general alloying is not of such great value as often expected.

Hatfield,[38] in his book, writes "It cannot be said, as in the case of steel, that the special elements are alloyed with cast iron with great advantage. The condition of the carbon is the essential determining cause of the variable characteristics of the iron, the influence of additional elements are mainly of value as regards modification in this subject. By varying the percentages of the elements normally present, the condition of the carbon can be adequately controlled more cheaply than by adding more expensive elements."

From Maurer's cast iron diagram, we know that the proper relation between the iron and silicon content is a most important factor in obtaining an essential improvement by any additional treatment or special metallurgical process, as superheating. After a careful study of the subject, Piwowarsky's conclusions[39] summarizing his views are along the same line. He writes, "In comparing alloying with the other proposed improvements, the addition of special elements does not seem to be very hopeful. By varying the silicon and carbon content as required for the purpose for which it is intended, and by diminishing the speed of cooling, cast iron can be produced with 50 kg./mm.^{2} (71,000 lbs./in.^{2}) bending strength even with the thinnest sections." Piwowarsky is of the opinion that it is possible to improve medium-grade cast irons by special additions, but the degree of improvement decreases considerably when alloys are added to irons, which already represent high-test material.

The two most comprehensive European investigations on the subject are those of Smalley[39] and Piwowarsky. Both authors investigated the influence of a large number of elements. The results of Smalley's tests in adding alloys to cylinder iron are briefly: copper up to about 0.5% increases the hardness slightly, but the other properties and the structure are not improved; 0.5% nickel results in refining the graphite crystallization with unchanged hardness; chromium improves hardness and bending strength; molybdenum has no influence below 0.5%, above this amount the quality is improved; tungsten has a similar influence to molybdenum but to a lesser degree; cerium, uranium, calcium, vanadium, zirconium, aluminum and magnesium have no essential influence.

Piwowarsky investigated 3 groups of iron with 1%, 1.75% and 2.75% silicon. Adding 0.02–0.08% aluminum to groups 1 and 2 brings about an increase in bending strength up to 25% and a 25–50% increase in notch toughness. In group 3, bending strength and notch toughness show only a slow increase. Aluminum favors graphitization. Titanium also favors graphitization, and maximum refining of the graphite is accomplished with 0.1% Ti, this improving the quality. A nickel content of 0.5–1.0% increases the physical properties by 20–30%. Above this amount, graphitization increases and the improvement diminishes. Contrary to Smalley, Piwowarsky could not find any refining of graphite. A chromium addition results in no marked improvement, unless over 10%. The best results are obtained with additions of nickel and chromium combined. The best properties are obtained by adding 0.5% Cr and 0.2% Ni to group 1, and 0.4 to 0.8% Ni to groups 2 and 3. The increase in properties amounted to as high as 75% in group 1, up to 80% in group 2, and up to 60% in group 3. The formation of graphite is not as favored by chromium as when it is present alone. Vanadium favors carbide formation and therefore increases the hardness very sharply above 0.5%. This influence was more pronounced with the lower silicon iron (groups 1 and 2). These results contradict those of Smalley, who doubts the hardness increasing tendency of vanadium. The addition of vanadium seems important in the production of products with high shock and wear resistance. Tungsten was added in amounts of 0.25–0.50%; 0.5% W increases the properties considerably. Molybdenum above 0.5% acts similarly to tungsten. Above 1% the improvement is not pronounced. It may be mentioned here, that these results are in complete accordance with the recent American work of Smith and Aufderhaar[40] who found an increase of from 26,000–45,000 lbs./in.^{2} as a result of a 1% Mo addition. Piwowarsky summarizes as follows: Al, Ti, Ni are alloying elements, where good machinability is essential; Cr together with Ni results in dense, fine grain castings; higher strength with high toughness is obtained with Va; Mo and W together hold the greatest promise for improvement. In going through his paper, the fact cannot be overlooked that in the best case the bending strength of the unalloyed iron could be raised to 52 kg./mm.^{2} (73,800 lbs./in.^{2}).

Doubtless the American foundryman has devoted himself more to the improvement by means of alloying and having more experience in this, it is not surprising that alloying is emphasized more here than abroad. This can be seen from the papers read in recent years before the American Society for Testing Materials[41] and the American Foundrymen's Association.[42] It is not the object of this survey to cover this work in detail, the less so, as the mentioned societies have considerable material on the properties and applicability of cast iron in preparation.

The more recent articles in METALS & ALLOYS[43] assure the American foundrymen that as Moldenke[44] stated, "the means for a 'come-back' of cast iron are at hand, and the avidity with which foundrymen are grasping their opportunity argues for a brighter era ahead of the gray iron industry."

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Critical Abstract

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts of a critical nature on articles of special importance. The current literature will be covered in the Abstracts of Current Metallurgical Literature.

Railway Rail Progress

Bulletin 324, Feb. 1930, Pages 1460–1667, American Railway Engineering Association, contains several reports and comments on progress being made in the attempt to reduce rail failures.

In the first year of operation, the Detector Car tested 2908 track miles, and detected 213 transverse fissures or 1 per 13.6 track miles. Reporting roads found last year 5458 transverse fissure failures in 149,000 track miles, or 1 per 27.3 track miles. Thus the detector car finds fissures twice as fast as they are met in normal failure. It detects fissures as large as a five-cent piece but does not yet pick up smaller ones.

Failures in a short period after track has been tested by the car indicate rapid growth of fissures from a size smaller than a nickel to complete failure.

Data on a total of 37,797 transverse fissure failures are now in the hands of the A. R. E. A.

The percentage of 1927 and 1928 transverse fissure failures segregated as to months of rolling shows an interesting correlation with temperature. The combined average for June, July and August is 4.6%, for May and Sept. 6.7%, for April and October 8%, all these running below the $8\frac{1}{3}$% figure that would be expected if atmospheric temperature had no effect, while Nov. to March run from 9.5 to 13.5%.

Statistical studies have been made showing the intensity of traffic since 1905 and its trend. The 1905–1913 trend, as it would have been extrapolated from that data alone, would have predicted a present intensity of but 4 million ton miles per mile of track while the actual present figure is nearly 6 million, and in 10 years more is expected to be 7 million.

The trend or "dream curve" of rail failures as projected from the 1913–1919 failures led to an expectation for the present time of 1 rail failure per 2 miles of track, while it is actually running about 1 failure per mile. Hence traffic density corrections have to be made in all statistical studies. The rail section has steadily increased so that many variables have to be considered in studying rail data.

Intermediate manganese (1.30–1.60% Mn) rails are in use on 9 roads to the extent of 377,000 tons. Reports on their service are, in general, favorable. The four largest users, N. Y. Central, C. B. & Q., D. L. & W. and A. T. & S. F., all report a smaller proportion of transverse fissures than in comparison rail, and in general, reduced wear. The only adverse report is from the Pennsylvania, on only 942 tons, of 1.40–1.70% Mn rail. This showed a high proportion of split head failures and no improved resistance to abrasion.

The most interesting part of the Rail Committee's report and appendices will, to most metallurgists, be that dealing with heat-treated rails.

The Carnegie Steel Company, Edgar Thompson Works, has treated rails by heating them up from the cold, oil-quenching and drawing while still warm, while the Bethlehem Steel Company, Steelton Plant, has taken the rails direct from the rolls, quenching head down in water for 15 to 45 seconds, then drawing immediately.

About 500 water-quenched rails are in service on the B. & M., B. & O., D. L. & W., Lehigh Valley, N. Y. Central and Reading, and 34 oil-quenched rails on the B. & O., N. & W. and P. & L. E., beside some 270 of both varieties being tried by the Pennsylvania as a result of earlier tests on some 65 or more heat-treated rails.

The experience of the Pennsylvania is described by W. C. Cushing, Engineer of Standards, in "Rail and Wheel—Part IV—The Heat-treated Rails in the Tracks" (pages 1619–1666).

The resistance to abrasion of the heat-treated rail appears, on the whole, to be superior to that of comparison rail though it is greatly affected by the length of time in quenching in the rails water-quenched from the hot-saw. Transverse fissures different in appearance from the usual type, were found in one rail quenched for 45 seconds or more and in one quenched for 30 seconds which came from the quench with excessive camber and which later examination indicated was "in a poor condition to withstand heat-treatment." This rail had a transverse crack somewhat similar to the common shatter crack through a segregated streak. An important observation was that the rails quenched from the hot-saw, in general showed "an improvement in reduction of tendency toward internal shattering."

The tests included some rather poor rails, intentionally chosen to see what heat-treatment would do on such material, and a large number of variables in heat-treatment were tried. Cushing concludes that in order to secure sound metal, suitable for heat-treatment in rails, slag and inclusions must be eliminated to the greatest possible degree, and big-end-up, hot-top ingots used. With sound and clean metal at the start, heat-treatment can produce rails with 60% higher elastic limit, 25% higher ultimate strength, elongation increased by 35% and reduction of area by 140%, and 20 to 36% increased hardness. To secure optimum results, very precise time and temperature control of heat-treatment operations will be required. Cushing's own idea of the possibilities in heat-treated rails is evidenced by the heading he uses for his report, "New Era Rails."

It is emphasized in the report that the Bethlehem and Carnegie developments were made wholly at the expense of the mills.

From the point of view of the riding public, the efforts being made by the railroads, to eliminate faulty rails by use of the detector car, to install better rails by the adoption of intermediate manganese rails as fast as they prove their worthiness, and most of all the effort toward a large, rather than a minor, improvement in properties by the current trials of heat-treated rails, together with the cordial cooperation of progressive rail-mills, deserve high commendation.

The metallurgist, appreciating the difficulty of, and the expense for proper equipment for, heat-treatment of such a thing as a 33 ft. or longer rail, can but admire the nerve of those who are tackling the job, and wish them luck.—H. W. Gillett.

Abstracts of Current Metallurgical Literature

These abstracts are not critical, but merely review developments as they are recorded. Beginning with this issue the various classifications are numbered. This number is at the end of each abstract and will be of assistance in mounting them on cards for filing.

GENERAL (0)

Metallurgy of Drilling Equipment. H. W. Fletcher. *Bulletin* No. 204, *American Petroleum Institute*, Jan. 2, 1930, pages 94–101.

Modern deep drilling has forced a notable improvement in the materials on the rotary rig. Alloy steels now in general use have overcome many of the difficulties formerly experienced. Heat treatment enables the manufacturer to modify physical properties to meet specific service requirements. Rigid control of material and manufacturing processes is essential to maintain the required uniformity of properties. (0)

Metallurgy of Steels and Need for Standardization in Oil Field Equipment. J. H. Reece. Paper at fall meeting, Rocky Mountain district, American Petroleum Institute, Casper, Wyo., Nov. 20, 21, 1929.

The author discussed importance of steel in modern life and then briefly describes the methods of steel manufacture, in conclusion, he suggests that standards be adopted covering grade and quality desired in oil industry. (0)

Magnesium, Magnesium-Rich Alloys and Beryllium Alloys. T. Henry Turner. *Metal Industry*, London, Jan. 17, 1930, Vol. 36, pages 85–89.

Magnesium alloy castings are produced at approximately the same price as aluminum alloy castings, although magnesium costs twice as much as a cubic foot of aluminum. The problem of casting these alloys in sand has been solved. The castings may be easily worked. In common with other metals magnesium alloys require protection from certain corrosive atmospheres and liquids. Magnesium alloys are used in printing, textile, instruments, machine tool industries, etc. Beryllium is being produced commercially by the electrolysis of fused salts at high temperature, approximately 1300° C. A promising development is the production of beryllium alloys of copper and nickel to be used as temper alloys. VSP(0)

Developments in the Metallurgy of Copper. *Metal Industry*, London, Jan. 17, 1930, Vol. 36, pages 61–63.

Refers briefly to mining and production. Discusses uses of copper for electric conductors. Recent studies on casting copper and other metals gives a better control over quality of finished product. Beryllium as a deoxidizer for cast copper has recently been proposed. Much controversy exists as to relative value of "tough pitch" and "deoxidized" copper for special engineering requirements. The B. E. S. A. arsenical copper is still widely used for engineering applications. Considers silicon-copper alloys used in England, Germany and United States. VSP(0)

Notes on Alloy Steels; Some Lesser-Known Facts. J. H. Andrew. *Foundry Trade Journal*, Dec. 5, 1929, Vol. 41, pages 411–412; *Mechanical World*, Jan. 10, 1930, pages 37–39; Jan. 17, 1930, pages 54–56; *Iron & Coal Trades Review*, Nov. 29, 1929, pages 833–840; *American Metal Market*, Vol. 36, Dec. 21, 1929, pages 8 & 10.

Abstract of paper read before the Institution of Engineers and Shipbuilders in Scotland. Author states that the smaller the dendritic pattern, in the cast state, the better the ingot. Gives results of mechanical tests. Test pieces were normalized oil-hardened and tempered. Results show that correctly heat treated large castings, provided they are sound, will give mechanical tests almost equal to forged and treated ingot. If nickel and chromium are added to iron in small quantities, between 1 and 4%, they do not have any great effect on mechanical properties; when added to steel, their effect is considerable. Oil hardening cools the steel rapidly through the temperature of transformation, in order to retard that transformation, and cause it to occur at a temperature lower than the normal. When required to soften for machining any nickel-chromium or certain other alloy steels, the safest method is to heat it at about 650° C., followed if possible by fairly rapid cooling. WHB & VSP(0)

Plumbum Nigrum. S. J. Nightingale. *Metal Industry*, London, Jan. 17, 1930, Vol. 36, pages 71–74.

Describes both the new and ancient uses of lead. Commercial grades of lead have a tensile strength of 0.9 tons per sq. in, elongation of 80%, and a Brinell hardness of 3.2. Some of the uses are in building trades, and in chemical industries. Sulphuric acid industry utilizes vast quantities for linings of vats, stills, coolers, etc. Ternary alloys of lead are used where a greatly improved mechanical strength is the first consideration. VSP(0)

Uses of Electricity in the Development and Manufacture of Tool Steel. O. K. Parmiter. *Iron & Steel Engineer*, March 1930, Vol. 7, pages 122–124.

The application of arc and high frequency melting furnaces to the production of high alloy steels such as high speed steel is discussed. Electric melting is superseding the crucible process. Electric drives for rolling mills and electric heat treatment are also discussed. The uses of electricity in the laboratory for electrolytic, electromagnetic and spectrum analyses are noted. Lastly the use of electricity in the manufacture of cemented tungsten carbide is mentioned. WHK(0)

Recent Developments in the Metallurgy of Cast Iron. Dr. R. Moldenke. *Metals & Alloys*, Jan. 1930, Vol. 1, pages 327–28.

Cast iron melted under ordinary conditions of superheating retains minute particles of undissolved graphite in suspension which form nuclei for growth of graphite crystals as the metal freezes. Additional heating to 2800° F. however, dissolves them. When cooled the graphite freezes, then, crystallizes out in a very fine form with resultant greatly increased strength. Series of samples chilled from 2400–2850° shows no nuclei at higher temperature treatment under microscope. Tensile test pieces show more than doubling of strength for the latter treatment. Silicon and manganese should be high and phosphorus and iron sulphide low for best results. An excellent analysis is C 2.75, Si 2.75, Mn 1.00, P 0.08. The desirable pearlitic structure obtained with low silicon iron poured into hot molds. Low (1.75) silicon casts into cementite which, when annealed at 1600°, breaks down and results in excellent malleable iron. ESC(0)

Fifty Years of Physical Metallurgy. H. W. Boylston. *Metals & Alloys*, Jan. 1930, Vol. 1, pages 329–331.

A brief résumé of science of physical metallurgy from its earliest developments. Metallography includes not only the visual and microscopic examination of metals but also their study by means of thermo analysis, magnetic properties and thermo analysis, dilation, calorimetric and pyrometric charges and conductivity. Physical metallurgy may be defined as that science which deals with the study of the physical properties of metals and alloys with special reference to their microstructure. Sauveur improved microscopic equipment in 1894. Various investigations began to measure physical properties. High-speed steels were developed in 1900. The following decade is marked by numerous publications and researches. Alloy steels arrived in 1910. Sauveur theory of hardness has evoked much study and discussion. Enlightenment regarding crystalline growth has advanced the science of non-ferrous alloys. The phase diagram of the iron–carbon system is well defined. ESC(0)

PROPERTIES OF METALS (1)

Lithium. Freiherr von Girsewald. *Metallgesellschaft*, Nov. 1929, pages 13–19; *Chemical Trade Journal*, Dec. 27, 1939, Vol. 85, pages 621–622.

This article gives the properties of lithium metal and in great detail the development of the new production method. Metallic lithium imparts to other metals, even when only a few hundredths % are added, a degree of hardness which cannot be attained by other means. It is also used for purifying other metals. Lithium hydroxide is used in storage batteries to increase the capacity of the cell. MLM(1)

Melting, Mechanical Working and Some Physical Properties of Rhodium. Wm. H. Swanger. *Bureau of Standards Journal of Research*, Dec. 1929, Vol. 3, pages 1029–1040.

See *Metals & Alloys*, March 1930, Vol. 1, page 424. (1)

Thermal Expansion of Tantalum. Peter Hidnert. *Bureau of Standards Journal of Research*, May 1929, Vol. 2, pages 887–896.

This paper gives data on the linear thermal expansion of 3 samples of worked and annealed tantalum over various temperature ranges between −190° and +500° C. A summary of available data by previous observers on the thermal expansion of tantalum is included. Worked tantalum was found to expand practically the same as annealed tantalum. The following equation is given as the most probable second-degree equation for the expansion of tantalum between 20° and 500° C.: $L_t = L_o[1 + (6.59t + 0.00008t^2)10^{-6}]$. The coefficient of expansion of tantalum increases slightly with temperature. From 20–100° C. the average coefficient of expansion is 6.6×10^{-6} per degree centigrade. Table 6 gives additional coefficients of expansion for various temperature ranges. (1)

A new determination of the Melting Point of Palladium. C. O. Fairchild, W. H. Hoover & M. F. Peters. *Bureau of Standards Journal of Research*, May 1929, Vol. 2, pages 931–962.

The melting point of palladium was determined by measuring with an optical pyrometer the ratio of brightness of the red light ($\lambda = 0.6528\ \mu$) emitted by black bodies at the melting points of palladium and gold, respectively. The crucible method was shown to be more reliable than the the wire method. Especial attention was given to the purity of the metals. The result obtained by the crucible method when substituted in Wien's or Planck's equation, gives the melting point of palladium as 1556.6° C. with an uncertainty of 1°. In the computations C_2 was taken as 1.432 cm. deg. and the melting point of gold as 1063° C. The average of the present result, and those of 6 previous determinations, is 1553° ± 0.7°. Estimating the uncertainty of C_2 as 0.002 and in the melting point of gold as 0.5°, it is concluded that the uncertainty in the value of the melting point of palladium on the centigrade thermodynamic scale is approximately 2°. (1)

PROPERTIES OF NON-FERROUS ALLOYS (2)

Aluminium Casting Alloys. *Brass World*, March 1930, Vol. 26, pages 65–66.

A note on the aluminum casting industry in England and a tabular summary of compositions and properties of B. E. S. A. aluminum casting alloys. Fields of application of various standardized aluminum alloys are briefly indicated. WHB(2)

Determining the Shrinkage of Liquid Metal in Cooling. *American Machinist*, Feb. 20, 1930, Vol. 72, page 346.

Brief report of an investigation being carried on through the cooperation of the American Foundrymen's Association and the U. S. Bureau of Standards under the direction of E. J. Ash. The "crucible immersion method" is being used. Solidification shrinkage of 98.5% aluminum, based on liquid volume at 656° C. is 6.4%. RHP(2)

Some Recently Introduced Aluminium Alloys. W. C. Devereux. *Metal Industry*, London, Jan. 24, 1930, Vol. 36, pages 117-120; *Foundry Trade Journal*, Jan. 23, 1930, Vol. 42, pages 68–70; *Chemical Age*, Feb. 1, 1930, Vol. 22, Met. Sec., page 10; *American Machinist*, Jan. 12, 1930, Vol. 72, pages 251–252 E.

Includes discussion. Paper read before the Institution of Production Engineers. An alloy known as "R. R. 50" which is regarded in aircraft industry as representing a distinct advance in the use of aluminum. Its coposition is as follows:

Copper.....	0.5–5.0%	Titanium.....	up–0.5%
Nickel.....	0.2–1.5%	Silicon.....	0.2–5.0%
Iron.....	0.6–1.5%	Aluminum.....	Remainder
Magnesium....	0.1–5.0%		

The range is wide, and the elements are divided into 4 grades: one for die castings for pistons; one for general sand and die castings; another for forgings for general purposes; and a fourth for forgings suitable for high quality pistons. Considers other recently introduced alloys and compares their properties with "R. R. 50." Includes a discussion of its applications and treatment. VSP & RHP(2)

Brass and Bronze. Reginald G. Johnston. *Metal Industry*, London, Jan. 17, 1903, Vol. 36, pages 64–66.

Gives account of the modern uses of brass and bronze. Higher copper alloys of great purity fall into 2 groups: , those containing more than 64% copper and those with less. The former are suited for deep drawing and stamping, and for processes involving severe mechanical deformation. Purity of high copper brass has to be kept very high for extruding rods and tubes. Season cracking is well understood and its prevention is a mere routine operation. Brass is still the most important alloy used for tubes, in spite of numerous rival alloys. There are several types of bronze suitable for special purposes. Small amounts of tin added to copper greatly change the properties of the copper. High tin bronzes quickly chilled are hard and strong, but with a tendency to be brittle. When slowly cooled, if tin is not above 8%, they may be rolled and drawn. VSP(2)

French Foundry Casts Silicon-Aluminum Alloy. Vincent Delport. *Foundry*, March 1, 1930, Vol. 58, pages 121–122.

Discusses the use of a modified 13% silicon-aluminum alloy in the production of automobile parts, parts for airplanes, for diesel engines and for railroad rolling stock. The density of the alloy is 2.6. It presents about the same resistance to corrosion by atmospheric agents as pure aluminum. Contraction of the alloy is similar to that of cast iron. The minimum tensile strength is said to be 27,000 lbs. per square inch, with an elongation of over 5%. Includes a brief historical discussion of the use of this alloy, and gives data on the manufacture of castings by the Forges de Crans in France. VSP(2)

Advances in Die-Cast Metals for Automotive Use. C. PACK. *Preprint* for March 1930, *Automotive Symposium, American Society for Testing Materials*, 9 pages; *American Metal Market*, Apr. 9, 1930, Vol. 37, pages 2 & 10; Apr. 10, 1930, page 10.

Zinc base die casting alloys containing about 3% Cu, 4% Al and 0.1% Mg have about 48,000 lbs./in.² tensile strength, 3% elongation, and after 20 days in steam at 95° C., lose 20% of their initial tensile strength. The zinc should be 99.99% pure. This purity is obtainable in electrolytic zinc. Iron is picked up from the melting pot and should be held below 0.1%. Lead and cadmium are undesirable impurities, and must be held below 0.05% each, and would be better held below that. No tin can be allowed, even 0.01% is fatal to stability. It is practically impossible to avoid contamination of die castings made in a plant that also produces tin-base or lead-base alloys. In aluminum alloys for die castings, several compositions, with Cu, Si and Ni as alloying elements are used. The best all round alloy is 4% Cu, 5% Si, 91% Al. Because die castings contain blowholes which blister in heat-treatment, heat-treatment is not applied to these alloys. The possibilities in die casting magnesium-base and copper-base alloys are briefly discussed. HWG(2)

A Study of Barium Tin Alloys. K. W. RAY & R. G. THOMPSON. *Metals & Alloys*, Jan. 1930, Vol. 1, pages 314–316.

Alloys of barium and tin containing as high as 30% barium have been prepared and the thermal diagram constructed. Two compounds $BaSn_3$ and $BaSn_5$ are formed. Additions of barium increases the hardness and brittleness and the rate of corrosion of the alloys. Addition of barium decreases the specific gravity of the alloys. ESC(2)

On the Equilibrium Diagram Cobalt-Chromium, the Properties of Cobalt-Chromium Alloys and the Influence of Some Elements on the Properties of Cobalt-Chromium Alloys. (Ueber das Zweistoff-System Kobalt-Chrom mit einem Beitrag zur Kenntnis der Eigenschaften von Kobalt-Chromlegierungen, und einem Anhang über den Einfluss einiger Elemente auf die Eigenschaften der Kobalt-Chrom Legierungen.) F. WEVER & NICHI HASCHIMOTO. *Mitteilungen Kaiser Wilhelm Institut für Eisenforschung*, 1929, No. 19, Report 137, pages 293–330; condensed in *Stahl und Eisen*, Feb. 20, 1930, Vol. 50, pages 235–238.

F. Wever and N. Haschimoto undertook the investigation in consequence of the increasing demand for heat resisting alloys in machine construction. The equilibrium system Co–Cr was again established by thermal, metallographic, physical, magnetic and X-ray tests. Co and Cr mix in liquid state in all proportions. The liquids branch of the diagram has a minimum at 42% Cr and 1409° C; this composition crystalllizes as a eutectic composed of a Co solid solution with 40% Cr and a Cr solid solution with 51% Cr. In consequence of the low diffusion velocity of Co essential differences in composition are observable. The Co-solid solution is cubic face-centered at high temperatures and hexagonal at low temperatures. The maximum solubility of the hexagonal solid solution for Cr is 32% at room temperature. The Cr-solid solution with 57.5% crystallizes as a very brittle compound Co_2Cr_3 at 1291° C. It probably exists as another compound CoCr. CoCr crystallizes tetragonal with 8 molecules CoCr in the lattice unit. CoCr crystallizes, in comparison with Co_2Cr_3, only very slowly. The homogeneous solid solutions up to 32% Cr, only have practical application. Compounds of higher Cr contents are very brittle. Forging can be easily performed between 1000° and 1150° C. Machining is impossible in consequence of immense hardness and toughness. Hardness at room temperature increases slowly for the Co-solid solution with increasing Cr contents, faster with higher Cr contents. An increase in hardness by adding more than 30% Cr is not advisable. The curve for tensile strength at room temperature is similar to the hardness curve. An annealed 30% Cr alloy has a maximum tensile strength of 90 kg./mm.², 4.5% elongation, and 10% reduction of area. Co-Cr alloys show heat-resisting properties. Alloy 70 Co, 30 Cr at 600° C. still has 86 kg./mm.² tensile strength, 7% elongation and 12% reduction of area; at 1000° C. 20 kg./mm.² tensile strength, elongation and reduction of area each 40%. Heat resistance was examined by scaling tests. Good heat resisting properties are in line with excellent resistance to acid attack. Alloy 70 Co 30 Cr is very well suited for machine parts subjected to high temperatures. Additional elements were added to find further improvements. Fe, Mn and Si impair physical as well as chemical properties. The solubility of C in Co-Cr solid solutions decreases with increasing C contents. A Co-Cr-Fe diagram was roughly established. Ni gives no essential improvement but may be alloyed with Cr instead of Co in consequence of the lower price. Alloying of W results in no essential improvement, but Mo the more. GN(2)

Commercial Aluminium Alloys from the Users' Point of View. J. B. HOBLYN. *Automobile Engineer*, Jan. 1930, Vol. 20, page 31–38.

Three alloys have the following composition and properties are discussed. The alloys are known as L.5, L.8 and "y."

L.5 alloy

Chemical composition.

Zinc.....	not less than 12.50 or more than 14.50%.
Copper.....	not less than 2.50 or more than 3.00%.
Aluminum.....	remainder
Impurities.....	allowed up to 2%

Mechanical specification on a bar turned to the usual standard dimensions for the chill bar test were: ultimate tensile strength not less than 11 tons/in.², elongation not less than 3%.

L.8 alloy

Chemical composition.

Copper.....	not less than 11 or more than 13%
Aluminum.....	remainder
Impurities.....	allowed up to 2.3%

Chill bar test, ultimate tensile strength not less than 9 tons/in.²

"y" alloy

Chemical composition.

Copper.....	not less than 3.50 or more than 4.50%
Nickel.....	not less than 1.80 or more than 2.30%
Magnesium....	not less than 1.20 or more than 1.70%
Aluminum.....	remainder
Impurities.....	allowed up to 1.2%

Chill bar test, ultimate tensile strength not less than 11 tons/in.²

Gives tables and diagrams showing the mechanical properties secured by various treatments. Attempts to show the relation between and the effect of water quenching, annealing. Brinell hardness, tensile strength, yield point, elastic limit, and other mechanical and physical properties and the results obtained when in actual use in the automobile. RHP

Aluminum Bronze. *Machinery*, Jan. 1930, Vol. 36, page 379.

This alloy in its simplest form is 90% copper and 10% aluminum. With this composition the tensile strength is over 60,000 lbs./in.². Elongation 25%. It can be heat treated within the same range of temperatures as steel. By variation of the percentage of aluminum or by addition of other metals the physical properties may be changed to make it adaptable to many uses. Gives methods to be used in working and casting the metal, which will aid in the production of better castings. RHP(2)

Germanium XXXII. Alloys of Germanium. A Preliminary Study of the System Lead–Germanium. T. R. BRIGGS & W. S. BENEDICT. *Journal of Physical Chemistry*, Jan. 1930, Vol. 34, pages 173–177.

In a continuation of the studies on germanium alloys thermal data and an equilibrium diagram are given for the system Pb–Ge . The components appear to be consolute above the M.P. of Ge, the eutectic point coinciding with the M.P. of pure Pb. Photomicrographic evidence shows little likelihood of solid solutions. The Pb–Ge system is entirely analogous to the Si–Sn system as might be expected from the relative positions of the elements in the periodic system. A number of references to work on other alloys of Ge are given. WHK(2)

Germanium XXXI. Alloys of Germanium: Silver-Germanium. T. R. BRIGGS, R. O. MCDUFFIE & L. H. WILLISFORD. *Journal of Physical Chemistry*, July 1929, Vol. 33, pages 1080–1096.

A constitutional diagram for the Ag–Ge system has been formulated from thermal, micrographic and electrical conductivity data. A single eutectic was found at 74 atomic percent of Ag, the phases in equilibrium with the melt being pure Ge and a solid solution of Ge in Ag. The eutectic temperature is 650° C. The existence of the silver-rich solid solution was found by micrographic means, while the electrical conductivity data proved the absence of a germanium-rich solid solution. No evidence of compound formation could be found. Since the measured conductivities (of the Ge-rich alloy) fall far below those calculated from the law of mixtures it is concluded that the Ge (a very poor conductor) forms the continuous phase. Several references are given to work on analogous systems. WHK(2)

PROPERTIES OF FERROUS ALLOYS (3)

Nickel-Chromium Steels for High Temperature Service Valves and Bolts. V. T. MALCOLM. *Nickel Steel Data* No. 15, *International Nickel Co.*, 8 pages.

The article considers creep tests of nickel-chromium steels and gives characteristics of these steels for castings and bolts. (3)

Comparative Properties of Wrought Iron Made by Hand Puddling and by the Aston Process. HENRY S. RAWDON & A. O. KNIGHT. *Bureau of Standards Journal of Research*, Dec. 1929, Vol. 3, pages 953–992.

See *Metals & Alloys*, March 1930, Vol. 1, page 425. (3)

Application of Thermo-electricity to the Study and Control of Metallurgical Products. (Application de la thermo-électricite à l'étude et au contrôle des produits métallurgiques.) R. CAZAUD. *Aciers Speciaux, Métaux et Alliages*, March 1930, Vol. 5, pages 110 – 113.

Studies the effect of the nickel content upon the thermo-electromotive forces of nickel steels with varying carbon contents. Gives Brinell hardness curves and thermo-electromotive force curves of ordinary carbon steels as a function of the annealing temperature, the annealing taking place after quenching. AJM (3)

Gray Iron Possesses Valuable Engineering Properties. *Foundry*, Feb. 1, 1930, Vol. 58, pages 94–97.; Mar. 1, 1930, pages 107–110, 142.

Gray iron castings in the majority of places have given excellent service. Failures have also been recorded, which are traceable to the use of different grades of materials. Gray iron has good fluidity and its contraction is only about one-half that of steel and malleable iron. Tensile strength of the usual commercial grades is from 20,000 – 40,000 lbs./in.². Special grades with strength up to 60,000 lbs./in.² are obtainable. It has a low Young's modulus of elasticity ranging between 12,000,000 and 15,000,000 at 50% ultimate load value. Chilled spots can be eliminated by careful adjustment of mixture or use of alloys. It can be cast into intricate forms. Gives the A. S. T. M. and the British Engineering Standards Association specifications for gray iron. VSP(3)

CORROSION, EROSION, OXIDATION, PASSIVITY AND PROTECTION OF METALS AND ALLOYS (4)

Test Rack Aids in Corrosion Study. W. M. LAYTON. *Electric Journal*, March 1930, Vol. 27, pages 159.

A rack consisting of a wooden framework, upon which specimens are hung, permits observation of the effects of corrosion on materials and finishes, periodically. Frequent observations determine the relative extent of the deteriorating action of the sun's rays. WHB(4)

The Field Inspection of Protective Coatings Applied to Oil and Gas Lines. GORDON N. SCOTT. *Bulletin* No. 204, *American Petroleum Institute*, Jan. 2, 1930, pages 136–147.

Field inspections (449) of protective coatings on oil and gas pipe lines have been summarized. The data indicate that the percent of the inspections which showed that corrosion had occurred on the pipe subsequent to the application of the coating is markedly influenced by the corrosive character of the soils in which the coated pipes lay, the type of coating and the time the coatings had been in service. Although the various coatings behave somewhat differently in service this fact is subordinated by the rapidity with which the greater portion break down under service conditions. Felt reinforced treatments appear to maintain the pipe corrosion-free longer than do the other types of coatings. (4)

Corrosion and Pipe Line Coverings. CHARLES FITZGERALD. *Bulletin* No. 204, *American Petroleum Institute*, Jan. 2, 1930, pages 126–135.

Report of tests on pipe line coatings. Various types of corrosion illustrated by photographs. See *Metals & Alloys*, May 1930, Vol. 1, page 521. (4)

Pipe Line Currents. K. H. LOGAN, WALTER ROGERS & J. P. PUTNAM. *Bulletin* No. 204, *American Petroleum Institute*, Jan. 2, 1930, pages 116–125.

This paper describes some of the studies of various currents in the pipe. See *Metals & Alloys*, Vol. 1, May 1930, page 521. (4)

Effect of Oxidizing Conditions on Accelerated Electrolytic Corrosion Tests. HENRY S. RAWDON & W. A. TUCKER. *Bureau of Standards Journal of Research*, Sept. 1929, Vol. 3, pages 375–390; *Metal Industry* (London), Nov. 15, 1924, Vol. 35, pages 463-466.

Accelerated electrolytic corrosion tests were made on sheet copper and nickel in a sodium-chloride solution. Both anode and cathode were of the same metal, and the applied e. m. f. was relatively very low; the results are expressed as loss-of-weight-potential curves. The effect of oxidizing conditions was studied by surrounding the cell by an atmosphere of oxygen or nitrogen and/or dissolving the same gas in the electrolyte. The results clearly show the accelerating effect of oxygen on corrosion by reducing the potential necessary for a given corrosion rate. The results also have a distinct bearing on the theory of underwater corrosion as affected by conditions of differential oxidation within the solution. (4)

Rustless Steel Resists Severe Tests. *Iron Age*, Feb. 20, 1930, Vol. 125, page 594.

Discusses a rustless steel recently introduced by the Ford Motor Co., being an innovation in the automobile industry. The steel is resistant to rust, tarnish or corrosion. It is a chromium-nickel alloy steel containing 18% chromium and 8% nickel with low carbon content. VSP(4)

Report on Bureau of Standards Soil Corrosion Investigation. K. H. LOGAN. *Bulletin* No. 204, *American Petroleum Institute*, Jan. 2, 1930, pages 114–115.

This is a brief statement of the growth of organization and work on soil corrosion and protective coatings and projects now under way. The investigation is sub-divided into studies of the relation of soils to corrosion and studies of protective coatings. See *Metals & Alloys*, May 1930, Vol. 1, page 522. (4)

How to Avoid Loss by Pipe Corrosion. J. R. Baylis. *Water Works Engineering*, Jan. 1930, Vol. 83, pages 13–14.

Corrosion in water works engineering and treatment of the water, the only way in which the corrosion problem can be solved at the present time, is considered. GN(4)

Theory and Practice of Corrosion Resistant Equipment. Albert Portevin. *Iron Age*, Jan. 23, 1930, Vol. 125, page 306.

Abstract translation of paper read before the Conservatoire des Arts et Metiers in Paris. States that although at least 4000 investigations on corrosion had been made, the whole question is in a chaotic state. Platinum offers the ideal solution, but the high cost restricts its use. The introduction of stainless steel marks a veritable revolution in the use of metals. Other important metals discussed are: aluminum, nickel, cobalt, copper, molybdenum, vanadium, chromium and tungsten. VSP(4)

Protective Value of Chromium Plating. W. P. Barrow. *Metal Industry* (N. Y.), Feb. 1930, Vol. 28, pages 72–73.

Article taken from monthly review of the American Electroplaters' Society, December 1929. Being a progress report on work done through the research fund of the American Electroplaters' Society, the research will include: 1. Study of methods of measuring porosity of chromium coatings. 2. Effects on porosity caused by different conditions used in chromium plating. 3. Accelerated corrosion tests. 4. Atmospheric exposure tests. Discusses the first of these problems. Results refer simply to methods of testing. No final conclusions or recommendations are warranted from these results. VSP(4)

Corrosion and Heat-Resisting Steel as Applied to Automobile and Bus Use. C. M. Johnson. *Preprint for Automotive Symposium*, Detroit, March 1930, *American Society for Treating Materials*, 24 pages; *Heat Treating & Forging*, Apr. 1930, Vol. 16, pages 475–480; *Metals & Alloys*, Vol. 1 June 1930, pages 547–553.

After references to the important technical articles and patents describing these steels, Johnson discusses the superior resistance to oxidation at high temperatures conferred upon the 18% Cr, 8% Ni and 17% Cr, 25% Ni types by the addition of 2–3% Si. Silchrome valve steels are discussed and the addition of Ni and W to these mentioned. The corrosive attack of ferric sulphate, resulting from the combustion of fuel, upon ordinary steels and corrosion-resistant steels is discussed. Although it does corrode the resistant steels, its action is slight. A .35% C, 16% Cr, 15% Ni, 3% Si steel exposed 6 years to Pittsburgh atmosphere showed a loss after scouring off all dirt, corresponding to but 0.0003″ corrosion in the 6 years. A large amount of data is given on the physical properties of many steels differing in C, Cr, Ni and Si contents, as well as many comments on necessary precautions in working and treating. The data are too diffuse for abstracting and the original should be consulted. High temperature properties and the addition of S to improve machinability are discussed. Besides containing much data useful for reference, the paper is breezily written. HWG&MS (4)

Laboratory Corrosion Tests of Mild Steel, with Special Reference to Ship Plate. Henry S. Rawdon. *Bureau of Standards Journal of Research*, Feb. 1929, Vol. 2, pages 431–440.

Prompted by the claim that the ship plates of the Leviathan have shown evidence in service of outstanding superior corrosion resistance, a series of corrosion tests of mild steels, including some Leviathan and other ship plate, was made by the wet-and-dry and the continuous-immersion methods in the sea-salt solutions. The steels varied in copper content from a trace to over 0.60%. No differences in corrosion rate were obtained, indicating marked superior corrosion resistance of any of the compositions used. The differences in corrosion behavior observed were those resulting from difference in the test methods employed. The corrosion rate in the wet-and-dry test decreased as the surface film was built up but was always much higher than that for simple immersion. The laboratory test results have not confirmed in any way whatsoever the claims made for the Leviathan plate for unusual superior corrosion resistance. (4)

Boiler Reactions at High Temperatures. Boiler Corrosion at 10.54 and 14.06 kg./cm.² Pressure. Wayne L. Denman & Edward Bartow. *Industrial & Engineering Chemistry*, Jan. 1930, Vol. 22, pages 36–39.

Boiler corrosion has been studied under approximately actual operating conditions by means of a small laboratory boiler. It has been found that corrosion is directly proportional to the amount of dissolved oxygen; that caustic alkalinity, dichromates and arsenites inhibit corrosion when present in sufficient quantity; and that the removal of dissolved oxygen by means of reducing agents such as red-oak extract or sulphur dioxide results in greatly reduced corrosion. Removal of dissolved oxygen is accomplished with the minimum of corrosion by the use of oak extract. If an inhibitor such as potassium dichromate is used in the presence of a high chloride concentration, extreme care must be taken to insure the addition of sufficient inhibitor, otherwise localized corrosion occurs and the condition is worse than if no inhibitor is present. MEH(4)

Soil-Corrosion Studies, 1927-28. K. H. Logan. *Bureau of Standards Journal of Research*, Aug. 1929, Vol. 3, pages 275–302.

This paper is the second progress report on the soil-corrosion studies, supplementing *Technologic Paper* No. 368 which set forth the plan of the investigation, described the soils and materials under test, and gave the data obtained up to and including 1926. The present report supplements the earlier one, gives additional data on the chemical properties of the soils and materials, and records the results of the examination of specimens removed in 1928. These specimens include only ferrous pipe materials and cable sheaths, no specimens of non-ferrous materials other than cable sheaths, pipe coatings or galvanized sheet being removed. The results of some laboratory and special field investigations are described. Soil characteristics, rather than differences in the composition of the ferrous pipe materials, appear to determine the type and extent of the corrosion observed. Tables show the relative corrosiveness of soils based on rate of loss of weight and rate of increase in depth of pits. Although it happened that the soil was worst from both of these points of view, the soil that ranged next to the worst from the standpoint of pitting ranked twenty-eighth as to loss of weight. As the specimens in the ground grew older the corrosion became more general, and in most soils there was a decrease in the rate of penetration. Field examination of cast-iron gas mains in several cities yielded data of a similar nature. Preliminary studies indicated that, in addition to the highly localized galvanic action caused by mill scale, oxygen concentration cells, differences in soil contacts, etc., there are on long pipe lines galvanic currents that are the result of the line passing through different soils. There appeared to be a relation between the discharge of these galvanic currents and the corrosion observed on the pipe line. (4)

STRUCTURE OF METALS AND ALLOYS (5)

Metallography and Macrography (5a)

Metallographic Polishing. I. Automatic Metallographic Polishing Machine. S. Epstein & John P. Buckley. *Bureau of Standards Journal of Research*, Nov. 1929, Vol. 3, pages 783–794.

See *Metals & Alloys*, Nov. 1929, Vol. 1, pages 226–231. (5a)

The Relation Between Alpha-Veining and the A_3 Change in Iron. A critical abstract, H. S. Rawdon. *Metals & Alloys*, Jan. 1930, Vol. 1, pages 334–335.

Veining in ferrite grains forms only if the iron is transformed from the α into the γ condition. Mechanical deformation below A_1 or between A_1 and A_3 for a low carbon steel, as well as for electrolytic iron below A_3 does not result in veining. This phenomenon is fully explained. ESC(5a)

Preparation of Microsections of Tungsten Carbide. Samuel L. Hoyt. *Transactions American Society for Steel Treating*, Jan. 1930, Vol. 17, pages 54–58.

Includes discussion. Paper before the Eleventh Annual Convention American Society for Steel Treating, Cleveland, Sept. 1929. The specimen, which may be either broken off or cut out with a diamond saw is first ground to a plane surface on a silicon carbide wheel, grades known as 60-I, 80-H or 100-T having been found satisfactory. The next step is lapping with 140 to 200 mesh boron carbide (silicon carbide is not satisfactory here) moistened with kerosene on a smooth copper disc running at approximately 150 r. p. m. The final polish is given with No. 7 diamond dust (1.5 – 2μ) in almond oil on a wooden lap running at same speed. For fine work a further polish is given with No. 9 dust (about 0.5μ). Five minutes for the respective lapping operations has been found sufficient for specimens one quarter inch square. Boiling hydrogen peroxide and a mixture of 3 parts of 30% H_2F_2 with 1 part of conc. HNO_3 have been used for etching. Reference is made to "A Metallographic Study of Tungsten Carbide Alloys," by J. L. Gregg and C. W. Küttner, *Technical Publication* No. 184, *American Institute Mining & Metallurgical Engineers*, Feb. 1929, for further etching reagents. WHK(5a)

A Study of the Crystal Structures of Native Copper. H. C. H. Carpenter & M. S. Fisher. *Bulletin of the Institution of Mining & Metallurgy*, March 1930, No. 306, 32 pages and 14 plates; discussion, April 1930, No. 307, pages 3–16.

The microstructures of 20 specimens of native copper varied from oolitic markings, through zonal structures of various degrees of perfection, to irregular striations, with connecting links between the different types. All of the specimens were formed at low temperatures, probably by aqueous solutions of meteoric origin. In several cases, copper replaced cuprite, chalcocite, chalcopyrite, etc. At least one specimen was formed by rhythmic precipitation from gel. Oolitic markings are characteristic of copper formed by rhythmic precipitation; zonal and herringbone markings and irregular striations by replacement; columnar crystals with multiple twinning by aqueous action in general. Specimens recrystallized with heat treatment at 500–600° C. indicating a state of strain. All became homogeneous at less than 800° C. Since no specimen was homogeneous at first, the temperatures of formation must have been less than 800° C. Eighty excellent photographs are included. AHE (5a)

Structure and X-Ray Analysis (5b)

The Crystal Structures of Magnesium, Zinc and Cadmium Ferrites. E. Posnjak. *American Journal of Science*, Jan. 1930, Vol. 19, pages 67–70.

The ferrites were examined by X-rays, according to the power diffraction method. The length of the edge of the unit cube containing 8 molecules (Spinel type) for $MgO.Fe_2O_3$ is 8.36 ± .01 A.U.; for $ZnO.Fe_2O_3$, 8.41 ± .01 A.U. and for $CdO.Fe_2O_3$, 8.67 ± .01 A.U. The calculated and directly determined densities are: $MgO.Fe_2O_3$, 4.518 (4.481); $ZnO.Fe_2O_3$, 5.359 (5.290); $CdO.Fe_2O_3$, 5.835 (5.764). GN(5b)

X-Raying Large Steel Castings. Ancel St. John & Herbert R. Isenburger. *Iron Age*, Feb. 13, 1930, Vol. 125, pages 499–501. *Foundry*, Feb. 15, 1930, Vol. 58, pages 76–79; *Machinery*, Vol. 36, Feb. 1930, pages 431–434.

Discusses the X-ray inspection of heavy cast steel pipe fittings, weighing more than 3 tons each. The work of X-raying was done with temporary installations "on the job." 200,000 volt D. C. current was produced by special transformers and rectifiers. Approximately 125 X-ray pictures were required for the complete examination of a fitting. X-ray tests indicate that undesirable internal conditions of castings are all traceable to definite and simple causes. Lists undesirable conditions and states their causes. RHP & VSP(5b)

Dendritic Structure of Steel. H. G. Keshian. *Iron & Coal Trades Review*, Nov. 29, 1929, Vol. 119, page 840; Dec. 6, page 870. *Transactions American Society Steel Treating*, Mar. 1930, Vol. 17, pages 321–382.

The degree of dendritic structure is governed by the number and the size of the dendrites, which seems to depend principally on: 1. Casting temperature of the steel. 2. Chemical compostion. 3. Rate of solidification. The higher the casting temperature the larger the dendrites. Chemical composition seems to affect the intensity of dendritic structure: 1. By increasing or decreasing the center of crystallization. 2. By affecting the viscosity of the molten metal. 3. By affecting the surface tension of the molten metal, and by other ways. The more rapid the cooling the greater the number of small dendrites formed. If the cooling is rapid enough the formation of dendrites can be totally prevented. Discusses the crystalline nature of dendrites. Chemical, mechanical and physical properties and the segregation in dendritic steels are discussed. Microstructure and not the visible dendritic structure is the dominant factor in the development of physical properties. Dendritic steel containing 1% carbon showed 16% less fatigue resisting properties than non-dendritic steel of the same composition and with the same heat and mechanical treatment. Dendritic steel when tested transversely showed 23% less reduction of area than when tested longitudinally, while non-dendritic steel when tested transversely showed 9% less reduction of area than when tested longitudinally. Dendritic and non-dendritic carbon are practically equal in wearing properties. RHP(5b)

An Analysis of the Arc and Spark Spectra of Yttrium (Yt I and Yt II). William F. Meggers & Henry Norris Russell. *Bureau of Standards Journal of Research*, Apr. 1929, Vol. 2, pages 733–769.

All the available data (wave-length measurements and intensity estimates, temperature classes, Zeeman effects) on yttrium lines have been correlated and interpretated in an analysis of the arc and spark spectra. The total number of lines classified is 448 in the Yt I spectrum, 223 in the Yt II spectrum and 10 in the Yt III spectrum. Series-forming terms have been identified in each of the spectra, and from these the ionization potentials of 6.5 volts for the neutral Yt atom, 12.3 volts for the Yt^+ atom, and 20.6 volts for the Yt^{++} atom have been deduced. Yttrium is a chemical analogue of scandium, and the corresponding spectra are now seen to be strikingly similar. A ^2D term (from a "d" electron) represents the lowest energy (normal state) of both Sc III and Yt III, and another ^2D (from the s^2D configuration) describes the normal state of Sc I and of Yt I. The configurations which do not contain a d-electron are much lower in Yt II than in Sc II; a consequence of the fact that the s and p states in Yt III are lower compared with the d state than in Sc III. This results in $^1S_0(s^2)$ as the normal state for Yt II, while it is ^3D (sd) for Sc II. The analyses of Yt I and Yt II spectra are supported by measurements of Zeeman effects, which are interpreted with the aid of Landé's theory of Zeeman effects and multiplet structure. All details of the three spectra, Yt I, Yt II and Yt III, are in accord with Hund's correlation of spectral terms with electron configurations. (5b)

PHYSICAL, MECHANICAL AND MAGNETIC TESTING (6)

Apparatus for Thermomagnetic Analysis. Raymond L. Sanford. *Bureau of Standards Journal of Research*, Apr. 1929, Vol. 2, pages 659–670.

Thermomagnetic analysis consists in the study of magnetic effects occurring in a material during heating or cooling, with special reference to their interpretation in terms of structural changes or transformations. It is most conveniently carried out by means of a magnetometer of suitable type. The present paper describes thermomagnetic analysis apparatus set up at the Bureau of Standards and gives typical results obtained by its use. (6)

Testing Welds for Strength and Quality. *Machinery*, Feb. 1930, Vol. 36, pages 463–466.

Two general classes of tests are applied to welds; destructive and non-destructive. Both of these are discussed in this article, each from two viewpoints, that of the instruments and equipment used in the tests, and the information secured from these tests. Describes a hydrostatic test, stethoscope test, X-ray test, and several others. RHP(6)

Transverse Tests of H-Section Column Splices. JAMES H. EDWARDS, H. L. WHITTEMORE & A. H. STANG. *Bureau of Standards Journal of Research*, March 1929, Vol. 4, pages 395–413.

Plates were welded to the outer edge of the inside faces of the flanges of 3-foot lengths of 10, 12 and 14 inch H sections. The H sections were joined in pairs by splice plates bolted to these welded plates to represent a spliced section of column for use in a steel-frame building. The specimens so formed were tested as beams on a 66-inch span with loads at the quarter points. Four specimens were tested with the splice plates and H section webs parallel to the applied loads which were in a vertical plane, 3 specimens were tested with the splice plates and H section webs perpendicular to the applied loads. The behavior of the specimens is described and a method of stress analysis suitable for use in designing similar splices is developed. (6)

An Early Use of Magnetism for Mechanical Testing. S. R. WILLIAMS. *Instruments*, March 1930, Vol. 3, pages 157–158.

An historical sketch of the early work of Saxby (1867) upon magnetic testing of ferrous materials. WHK(6)

Analysis of Casing Stresses and California Casing Practice. C. J. COBERLY. *Bulletin* No. 204, *American Petroleum Institute*, Jan. 2, 1930, pages 22–42.

This paper is devoted to the study of the various possible forces encountered in oil well casings—approximating their magnitudes—and computing by the accepted formulas the strength of casing to withstand these forces. (6)

Stress Distribution and Plastic Flow in Elastic Plate with a Circular Hole. A. NADAI, V. R. BAUD & A. M. WAHL. *Mechanical Engineering*, March 1930, Vol. 52, pages 187–192.

The distribution of shearing stresses in a plate, large in width and with a circular hole, is calculated when subjected to tension, compression and pure shear. The calculation is checked by photoelastic tests. Compression tests with steel and hard copper illustrate the plastic flow in a compression member with a hole. Conclusions are drawn regarding safety factors in compression or tension members having a hole. GN(6)

Small Wire Tension Tester with Pendulum. *Wire & Wire Products*, Feb. 1930, Vol. 5, pages 55, 60.

The machine, built by Losenhausen Werke, Düsseldorff, Germany, has a capacity up to 10,000 lbs. and a double reading range from 0 to 10,000 lbs. and from 0 to 2000 lbs. The machine is equipped with special patented grip heads for rapid and easy handling and an elongation indicator. GN(6)

Recent Progress in Tests for Automotive Materials. H. F. MOORE. *Preprint* for March 1930, *Automotive Symposium, American Society for Testing Materials*, 10 pages.

General survey of testing problems relating to elastic failure, creep at high temperatures, repeated stress, impact, etc. The point of view in this discussion is more concerned with what the tests mean than with the details of how to make them. HWG(6)

Physical Properties of Electrically Welded Steel Tubing. H. L. WHITTEMORE, J. S. ADELSON & E. O. SEAQUIST. *Bureau of Standards Journal of Research*, April 1930, Vol. 4, pages 475–500.

This investigation was made for the purpose of determining the physical properties of tubing made from sheet steel in which the longitudinal seam was welded under pressure by the electrical-resistance method. Tubes ranging in outside diameter from $^5/_8$″–3″ and in wall thickness from 0.028–0.120″, inclusive, were tested in numerous ways to show the strength of the tube and the strength of the weld. With a variation of cold working a wide range of strengths were obtained without appreciable change in the carbon content of the steel. Most of the tubes were made from mild steel containing about 0.08% carbon, and a few were made from steel containing about 0.25% carbon. The average tensile strength of the tubes in full section varied from 54,000 lbs./in.^{2} for the arc-welded tubes to 74,000 lbs./in.^{2} for the hard-rolled tubes, and the compressive strengths in the axial crushing test of specimens $2^1/_2$″ long were practically the same. The welds were tested in (1) the hydrostatic test, (2) the tensile test of the welds in circumferential strips, (3) the torsion test, and (4) the axial crushing test. In the hydrostatic test, excepting the annealed tubes, only 1 of the 30 specimens fractured in the weld, but this at a high bursting strength. Only one of the 6 annealed specimens fractured outside of the weld. This showed that the annealing process reduced the strength of the weld about 10% below that of the base metal. In the tensile test of the welds in circumferential strips of 2″ tubes the longitudinal tensile strength was reached with no fractures in the welds except the annealed tubes. The strength of the weld of the annealed specimens was about 93% of the strength of the base metal as determined by testing strips with the weld outside of the reduced section. In the torsion test none of the tubes showed any fracture in the weld or in the base metal when the twisting was continued after the ultimate torque was reached. The average shearing stress in the extreme fiber at the proportional limit was, for swaged tubes, 22,610 lbs./in.^{2}, for rolled tubes 22,190 lbs./in.^{2}, and for hard-rolled tubes 30,310 lbs./in.^{2}. In the axial crushing test the weld was shown to have the strength and ductility to fold evenly with the base metal. There were a few exceptions in which cracks showed at the weld in the outer edges of the folds. Except in the case of swaged-annealed tubing, the properties of the base metal (the metal not affected by the welding operation) can be used in determining the working stresses for different structural uses of tubing made by the process used in the manufacture of this electrically welded tubing, no allowance being necessary for the altered structure in and adjacent to the weld. The properties at and near the weld for annealed tubing are sometimes slightly lower than the properties for the base metal. (6)

Creep Tests of Steel at High Temperatures (Dauerzugbeanspruchung von Stahl bei erhöhter Temperatur.) ECKARDT. *Veröffentlichungen des Zentral-Verbandes der Preussischen Dampfkessel-Ueberwachungs-Vereins*, 1929, Vol. VII, pages 5–71.

Tests extending over 2 years were made on the creep of steels under various loads at elevated temperatures, 300–600° C. The tests covered 21 heat treated carbon, low and high alloy steels, under tensile stress for periods of 8 to 311 hours. The test pieces were heated in an electrically heated salt bath equipped with automatic temperature control. The load was applied by dead weights and the creep or elongation was measured by a delicate mirror reflection arrangement which was sensitive to 0.0001 mm. The results are given in a large number of curves. An attempt was made to derive formulas, so that the behavior of a steel held at elevated temperature for lengthy periods can be predicted from one or two short time tests. From results of long time tests at constant temperature and under constant load an exponential relation was derived between increase in creep during a fixed time interval and the load. However, the rate of creep cannot be used to determine the durability of steel at elevated temperatures. An equation is derived for the relation of creep to time for singly and repeatedly stressed test pieces, and is proved by 200–300 hour tests. A table gives the allowable load for each of the steels tested, which will result in 2% elongation in 10 years at 460° C. Cr-Ni-W and Cr-V-Mo steels give best results. Complete tables, curves, photomicrographs, illustrations and bibliography are included. CEM (6)

More on Fatigue and High Frequency Testing. H. W. GILLETT. *Metals & Alloys*, Jan. 1930, Vol. 1, pages 332–333.

A critical review of "High Frequency Fatigue" Jenkin and Lehmann. Accelerated fatigue testing is carried out by suspending at its nodes a small flat strip of metal which has a high natural period of vibration and blowing air against it through a disc nozzle whose opening is at center. Ten million cycles can be imposed in a period of fifteen minutes by this means. Measurements are given for 0.11% C normalized steel, aluminum and armco iron. Tests indicate the fatigue limit increases with frequency. ESC(6)

Application of the Inverse Wiedemann Effect to Torque Measurements and to Torque Variation Recordings. T. KOBAYASI, K. SIMAMURA & T. KOYAMA. Part I, Report No. 52, *Aeronautical Research Institute, Tokyo Imperial University*, Nov. 1929, pages 425–445; Jan. 1930, Part II, Report No. 54, pages 1–4.

The effects produced by twisting iron rods 2–2.5 cm. in diameter are studied. The torque variations of an automobile engine crankshaft are measured and recorded by an oscillograph. (6)

The Magnetic Analysis Method of Metal Inspection. R. R. MOORE. *Trade-wind*, Feb. 1930, Vol. XII, pages 11–12.

This new method for analyzing steel bars from which airplane engine parts are machined was made necessary because physical and microscopic tests are not sufficient. The steel bars are placed through 2 magnetizable coils connected in series. In the center of each of these primary coils is a secondary coil. When the steel bar is passed through the magnetic field an e. m. f. is induced in the secondary coil. If the steel is free from defects the characteristics of this induced e. m. f. are the same as those of the primary current. An oscillograph is connected to the apparatus and on this is recorded the primary and secondary currents. This is a means of obtaining 100% inspection of bar stock with great speed and thoroughness. MLM(6)

Machines for Determining Torsional Fatigue Developed in Germany. *Automotive Industries*, Feb. 8, 1930, Vol. 62, pages 193–194.

Two new machines for testing specimens for endurance under alternating torsional loads are described. The machines are manufactured by Losenhausen, A. G., Düsseldorf, and Carl Schenck, Inc., Darmstadt, Germany. GN(6)

Approximate Relations Between Brinell, Rockwell and Shore Hardness and the Tensile Strengths of Structural Alloy Steels. *Nickel Steel Data*, No. 16, *International Nickel Co.*, 4 pages.

Conversion charts, table and formulas are given. (6)

Test Bars Vary with Size of Castings in New Standards. W. ROLAND NEEDHAM. *Iron Age*, Nov. 28, 1929, Vol. 124, page 1438.

Discusses new British Engineering Standards test pieces for cast iron. The tensile strength of gray iron decreases the thicker the sections, since rate of cooling affects the solidified metal. For transverse tests 3 sizes of circular bars are made to serve the 3 thickness ranges. The specification permits the use of bar either cast in or cast separately. VSP (6)

Making Use of Irregular Brinell Impressions. M. G. CORSON. *Mining & Metallurgy*, Feb. 1929, Vol. 10, pages 78–79.

States that an irregular impression indicates a peculiar state of internal forces. The metal tested is inclined to exhibit planes of weakness. Microphotographs of 2 sample alloys taken, 1 showed a round impression while the other was square. The sample with the round impression showed no slip bands. The square impressions showed 4 sets of slip bands symmetrically distributed. VSP (6)

The Deformation Process in a Test Bar. (Beiträge zum Verformungsvorgang in Zerreisstäben.) W. TAFEL & H. SCHOLZ. *Archiv für Eisenhüttenwesen*, Feb. 1930, Vol. 3, pages 545–552; *Discussion, Stahl und Eisen*, Vol. 50, Apr. 10, 1930, pages 484–485.

The influence of cylindrical shouldered ends on the distribution of stresses and the flow of metal within a test bar was studied. Electrolytic iron, wrought iron, copper and 2 steels (Atlas Steel and Krupp soft iron) were examined. The shoulders participate in the deformation and show parabolic shaped indentations on the head plane, when the shoulders are small enough to indicate any deformation. Making the shoulders different in height the fracture is always located closer to the smaller shoulder. Within certain limits the relation $h_1:h_2 = l_1:l_2$ is correct. In this relation h_1 and h_2 are the heights of the smaller and the larger shoulder respectively, and l_1 and l_2 the corresponding distances from the fractured cross-section to the shoulders. The average deformation of crystals was measured by means of a new method. The plastic deformation in a tensile test bar is a deformation of crystals as well as a displacement in regard to their relative location. The axial elongation of the crystals is at first larger in the neighborhood of the shoulders, as soon as the yield point is surpassed, than in the middle of the test bar, and increases from the shoulders to the middle when the breaking load is approached. Crystals in the center of the bar are deformed more than those near the surface. The differences of the axial elongation are practically zero at breaking load. W. Tafel is of the opinion that fracture occurs when the last differences of internal stresses within a test bar are equalized. GN(6)

Effect of Service on the Endurance Properties of Rail Steels. JOHN R. FREEMAN, JR. & HAIG N. SOLAKIAN. *Bureau of Standards Journal of Research*, Aug. 1929, Vol. 3, pages 205–246.

A series of tests have been carried out to determine the effect of service on the endurance properties of rail steels. In a previous report data were given on the endurance properties of steel from new rails. In the present report data are given on the endurance properties of steel from rails from the same heats after service and from 2 rails which failed due to a transverse fissure. It was found that the endurance properties of the steel were not affected by over 20,000,000 tons of traffic. In one group of rails very marked variation in results was found which was shown to be due to the presence of small internal cracks in the rails. Evidence was found which indicated that these rails probably contained small cracks before placing in service. It was concluded that the service stresses imposed had not measurably affected the endurance properties of the steel and, therefore, that the service stresses were less than the endurance limit of sound rail steel. (6)

ELECTRO-CHEMISTRY (7)

Electroplating (7a)

Accurate Current Density Regulation in the Chromium Bath. A. EYLES. *Brass World*, March 1930, Vol. 26, page 67.

An illustrated description showing the plating tank arrangement for accurate current control of a chromium plating bath. WHB(7a)

The Electro-Deposition of Silver from Argento-Cyanide Solution. SAMUEL GLASSTONE & EDWARD B. SANIGAR. *Metal Industry*, London, Jan. 30, 1930, Vol. 36, pages 8–10.

Contains discussion. Abstract of a paper read before the joint meeting of the Electroplaters' and Depositors' Technical Society and the Faraday Society. States that the addition of carbonate or excess free cyanide to argentocyanide decreases hardness of silver deposit. Formate, acetate, hydroxide, phosphate and sulphate cause hardening of deposit, while borate chloride increases hardening considerably. Deposits from sodium and potassium argentocyanides, are identical. Polarization is considerable during deposition, very small in excess free cyanides. Cathodic potential is influenced by alkali metal ions, and the hardness of the deposit by added anions. VSP(7a)

Notes on Chromium Plating. *Foundry Trade Journal*, March 6, 1930, Vol. 42, page 172.

Abstract of article in *Wirtschafts-und Export-zeitung*. States that chromium plating differs from other plating processes in that it is done with insoluble anodes. In this way, it is possible to plate in the most economical manner. VSP(7a)

Modern Chromium Plating Developments. *Metal Industry*, London, Jan. 24, 1930, Vol. 36, pages 121–123.

Describes new plant of Messrs. H. J. Nixon & Sons. The generator is motor driven and is rated at 1500 amperes at 10 volts and 720 r.p.m. The chromium vats, one of which is 9 ft. by 3 ft. by 4 ft. deep and the other 5 ft. by 3 ft. by 4 ft. 6 in. deep. They are constructed of 1/4-in. mold steel plate with welded corners. The merits of the Grauer & Weil solution here used are that it leaves the tank in a bright condition, requiring minimum buffing. The layout of the plant provides for the easy handling of the work. VSP(7a)

The Effect of Addition Agents Upon the Conductivity Cathodic Polarisation and Grain Size of Deposits Obtained from the Cell: Cu/Cu SO_4-H_2SO_4Cu. B. Clark & E. O. Jones. *Metal Industry*, London, January 30, 1930, Vol. 36, page 8.

Abstract of paper read before the joint meeting of the Electroplaters' and Depositors' Society and the Faraday Society. From experimental work authors conclude that the use of addition agent results in every case in: (a) An increase in cathodic polarization. (b) Decrease in conductivity of electrolyte. (c) Reduction in grain size of deposit, except when using peptone. VSP(7a)

The Spotting of Plated or Finished Metals. W. P. Barrows. *Bureau of Standards Journal of Research*, June 1929, Vol. 2, pages 1085–1116.

The American Electroplaters' Society, composed of foremen electroplaters, collected from their branches and from firms engaged in plating, funds to be used for researches on plating. The first problem selected for study was the "spotting out" of plated finishes, a defect which has proven very serious in such industries as the manufacture of builders' hardware. The investigation showed that there are 2 quite distinct defects that have been commonly included under the term "spotting out". The "crystal spots" consist of dendritic crystals which appear only on metals having an "oxidized" surface; that is, one colored with copper sulphide or other sulphides and subsequently lacquered. The "stain spots" appear especially on cast metals, either plain or lacquered, in the form of discolored areas of irregular shape, usually with a small dark spot near the center. The crystal spots have been found by X-ray examination to consist of cuprous sulphide (Cu_2S or chalcocite) growing usually between the layer of cuprous sulphide on the metal and the lacquer film. Their formation is caused or accelerated by sulphur in even minute amounts, such as may be derived from sulphur or hydrogen sulphide in the atmosphere or from rubber bands or wrapping paper or cardboard cartons. It was impossible to determine whether these traces of sulphur cause the slow formation of new cuprous sulphide in coarse crystals or the recrystallization of the very fine-grained cuprous sulphide already present. The only promising remedies are (a) exclusion of sulphur from the surroundings, (b) the use of lacquers found to retard spotting, (c) the application of a thin film of a grease, such as petrolatum, to the lacquered surface, and (d) the use of wax paper for wrapping. The stain spots are caused by the absorption in pores in the metal of acid or alkaline compounds during the plating process. Upon subsequent exposure to a high humidity such substances absorb moisture and exude upon and stain the surface. It was found that alkaline substances are especially difficult to remove from capillary pores. It is not practicable, however, to eliminate alkaline substances from the cleaning and plating solutions. In some cases the porosity of the metal may be reduced by a change in pattern or in casting conditions. No method of rinsing or neutralizing was entirely effective in removing the compounds. Baking at high temperatures before lacquering is sometimes helpful. The 2 most effective remedies are (a) permitting the chemicals to exude or spot out by exposing the articles to a high humidity before the final finishing, and (b) the application of a lacquer which has been found to retard this type of spotting. In general, phenol-condensation lacquers, which are less permeable to moisture than nitrocellulose lacquers, are also more effective in retarding stain spotting. Permeability to moisture is, however, not the only factor. Tests on many commercial lacquers of both types show that it is possible to develop lacquers which are much more effective for this purpose than the average nitrocellulose lacquers previously employed. (7a)

Electrolytic Gold Refining. Edmund Downs. *Metal Industry*, London, Jan. 24, 1930, Vol. 36, pages 141–143, 152; Jan. 31, 1930, pages 141–143; Feb. 7, 1930, pages 173–174; *Journal Electroplaters' & Depositors' Technical Society*, Vol. 5, pages 51–62.

Includes discussion. Condensed from paper read before the Electroplaters' and Depositors' Technical Society, Jan. 8, 1930. The process is similar to Wohlwill's electrolysis in 1874, and his process as described in 1898, apart from his introduction of a pulsating current. The reactions at the anode may be expressed:

$$1.\ HCl + Au + 3Cl' + 3\oplus = HAuCl_4 \text{ Auric.}$$
$$2.\ HCl + Au + Cl' + \oplus = HAuCl_2 \text{ Aurous.}$$

And at the Cathode

$$3.\ HAuCl_4 + 3H' + 3\ominus = Au + 4HCl.$$
$$4.\ HAuCl_2 + H' + \ominus = Au + 2HCl.$$

The concentration of gold chloride necessary in the electrolyte depends chiefly upon: The quality of the anode material; the working current density of the cell; and the temperature of the electrolyte. The current is an asymmetrical a.c. current consisting of a.c. superimposed on d.c. and is obtained by connecting a d.c. dynamo in series with an a.c. dynamo. The physical character of the gold depends upon the value of the current density, and may range from a dark deposit at high current to a bright yellow at normal current densitites. The impurities usually met with in gold anode are copper, bismuth, lead, selenium, tellurium, arsenic, etc. The composition of the slimes which fall from the anode depends upon impurities present in the bullion. VSP.(7a)

Progress in the Electroplating Industry. W. Pfanhauser. *Metal Industry*, London, Jan. 17, 1930, Vol. 36, pages 91–92.

Surveys the outstanding developments in the electroplating industry for the past year. A large number of establishments are using automatic machinery. In nickel plating current densities of 5–10 amp. per sq. dm. and even still higher are used. Production of deposits of micro-crystalline nature has shown advances. Chromium plating has created the greatest interest, and consequently a number of advances have been made. Cadmium plating has increased its field of application. VSP(7a)

Chromium Plating Technique in the Glass Industry. Frank P. Romanoff. *The Glass Industry*, Dec. 1930, Vol. 10, pages 285–290.

The requirements of chromium plating suitable for the protection of cast iron glass mold is discussed. Since composite coatings are not practicable, the chromium deposit must be fairly thick (about 0.0004") and without cracks that will expose the iron to corrosion. Methods and technique, including tank construction, plating formulas, current densities, bath contamination, and effect of shape of article being plated, etc., are discussed. WHK(7a)

Studies in the Electrodeposition of Metals. D. B. Keyes & S. Swann, Jr. *Bulletin* 206, *Engineering Experiment Station, University of Illinois*, May 20, 1930, Vol. 27, No. 38, 18 pages, price 10¢.

This records the results of experiments in the attempt to deposit Al, Be, B, Ti, Ce, Va, Cr, W from organic electrolytes. The only one with which any success was attained was Al. The fact, previously found by others, that the Gringnard compound, ethyl aluminum iodides, in ether, allow aluminum to be plated out, was verified. No quantitative statements as to current efficiency or as to the quality of the plating are given. It was also found that electrolysis at 100° C. of a mixture of aluminum bromide and tetraethyl ammonium bromide in molecular proportions produced a cathode deposit of aluminum and gave good anode efficiency, but the deposit was a mass of gray crystals. Apparently, only single experiments were made, and no further attempts are recorded to carry the work toward anything like a practical method for plating aluminum. HWG(7a)

New Work on Silver Plating. *Brass World*, March 1930, Vol. 26, pages 69–71.

A report of a paper on "The Electrodeposition of Silver from Argentocyanide Solutions" by S. Glasstone and E. B. Sanigar. The effects of added definite amounts of carbonate, sulphate, chloride, formate, hydroxide, acetate, cyanide, phosphate, nitrate and borate to different portions of a typical silver-plating solution were studied. The experiments were conducted with both potassium and sodium argentocyanide solutions. The following conclusions are drawn: (1) the addition of carbonate or excess free cyanide decreases the hardness of the silver deposit, (2) formate, acetate, hydroxide, phosphate and sulphate cause a hardening of the deposit, while borate and chloride increase the hardness considerably, (3) the deposits from sodium and from potassium argentocyanide solutions appear to be identical, (4) polarization during silver deposition is quite considerable in solutions containing carbonates, chlorides, phosphates, borates and hydroxides, but very small in the presence of a large excess of free cyanide—the polarization is slightly greater in sodium than in corresponding potassium solutions, (5) there is no obvious connection between cathodic polarization and the nature and hardness of the deposit. The cathodic potential is influenced mainly by the alkali metal ions, and the nature and the hardness of the deposit by the added ions, (6) the limiting current density at which silver can be deposited with 100% efficiency is a function of the silver concentration of the electrolyte and not of its conductance. WHB(7a)

METALLIC COATINGS OTHER THAN ELECTROPLATING (8)

Galvanizing Pot Destruction. Wallace G. Imhoff. *Iron Age*, Feb. 27, 1930, Vol. 125, pages 633–636.

The theory of galvanizing pot destruction is based along two lines of investigation: Influence of temperature in its relation to the contact of molten zinc upon iron or steel, and dissolving action of molten zinc at different temperatures. Discusses tests conducted. Eight different tests being made at temperatures ranging from 800–1500° F. The composition of the zinc used was:

	Iron by Precipitation	Iron by Titration
Antimony	0.000	———
Lead	0.000	———
Iron	0.1557	(0.0408)–(0.0343)
Aluminum	0.0459	———
Zinc (by difference)	99.7984	———

Results showed no appreciable loss of zinc by evaporation, but a considerable oxidation of zinc at high temperatures. Contains a number of illustrations. Describes resultant alloys. VSP(8)

Destruction of Galvanizing Pots. Wallace G. Imhoff. *Iron Age*, Jan. 23, 1930, Vol. 125, pages 294–297.

Pots having poor steel base and overheated pots fail quickly. Galvanizing pots are made of fire box steel and flange steel. The A.S.T.M. specifications for these steels are designated as specification A 30. Failures are usually traced to 3 definite causes in steel making: segregation, oxidation and mechanical defects. Gives examples under practical conditions showing pot failures. VSP(8)

Galvanic Coating of Wire with Cadmium. V. Hahn. *Wire & Wire Products*, Feb. 1930, Vol. 5, page 45.

Cadmium coatings have extraordinarily high rust-resisting properties, considerably greater than with any other kind of galvanizing. GN(8)

Plating Copper Wire with Tin. P. Siebe. *Wire & Wire Products*, March 1930, Vol. 5, pages 81–100.

The operation of tinning copper wire in a German plant is described. GN(8)

INDUSTRIAL USES AND APPLICATIONS (9)

Fabrication of Aircraft Fuselage. Charles E. Kirkbride. *Metal Stampings*, Feb. 1930, Vol. 3, pages 161–164.

From paper before International Acetylene Association. Welding has become standard method of fabrication of aircraft, chiefly in the construction of the fuselage. Rigidity is one of the most important factors resulting from use of a welded joint. Many features of welding, permitted in other industries, are prohibited in aircraft welding. These include tension welds, edge welding, making 2 welds too close together in thin gage material, filling holes with weld, and using any kind of welding rod. Metals adopted to welding are the Al alloy group, and C, Cr and Cr-Mo steels. Excellent joints in strong Al alloys are made using a 4.5% Si welding rod. With Al alloy all traces of welding flux must be removed as its presence will cause accelerated corrosion. MS(9)

Renewing Wheel Flanges. *American Machinist*, Feb. 13, 1930, Vol. 72 pages 305–306.

Car wheels of railway cars do not wear evenly and should be trued up every 50,000 miles. Previously car wheels had to be turned down to the size of the worst. By present methods the wheel is built up to normal size by welding. Wheels which are renewed at reasonable intervals can be welded at the rate of about a car per day. RHP(9)

10-Ton Crane Built of Aluminium Alloy. F. V. Hartman & E. C. Hartman. *Electrical World*, March 15, 1930, Vol. 95, page 552.

A 10-ton traveling crane has been installed in the U. S. Aluminum Co. works at Massena, N. Y. It is a 3-motor, single-hook machine with a lift of 22 ft. The bridge is fabricated from two double web girders spaced 7 ft. on centers. The girders are constructed of the strong aluminum alloys, and have a span of 72 ft. 2 inches. WHB(9)

Nickel Chromium Alloys. Utilization as Heat-Resisting Materials. Nickel Bulletin. *Chemical Trade Journal*, Feb. 21, 1930, Vol. 86, page 188.

"Cromite" is produced in the form of castings by the Chromite Foundry Co., Ltd., Tottenham, England. In the Coley process of zinc refining, the crushed ore is reduced in a revolving tube fitted with a worm feed. Most, of the equipment is constructed from chromite castings, also certain parts of the coal feed system. Chromite is used for pyrometer sheaths. Other applications include: retorts for carbonizing crushed wood, muffle furnaces, and nozzles and in the glass industry. WHB(9)

Zinc and Its Compounds. Wide Scope of Application. S. FIELD. *Metal Industry*, London, Jan. 17, 1930, Vol. 36, pages 75–76.
Sums up the industrial applications of metal and its various compounds. VSP(9)

Alloy Steels for Railroad Service. *Railway Mechanical Engineer*, Jan. 1930, Vol. 104, pages 37–40.
Abstract of a paper presented by Charles McKnight before the Railroad Division of the American Society of Mechanical Engineers Dec. 5, 1929. Includes discussion. The paper discusses properties and application of all kinds of alloy steels in the railroad field. GN(9)

Converting Steel into Locomotive Forgings. L. H. FRY. *Railway Mechanical Engineer*, March 1930, Vol. 104, pages 136–140.
The article considers points to be observed in the mechanical working of the steel for locomotive forgings and its heat treatment. GN(9)

Aluminum Alloys Serve Railroads. A. H. WOOLEN. *Railway Mechanical Engineer*, March 1930, Vol. 104, pages 142–144.
Abstract of a paper presented at the January meeting of the Western Railway Club, Chicago. Aluminum alloys and their use in the construction of cars and other equipment are considered. GN(9)

Developments in Light Metals and Alloys for Automotive Use. ZAY JEFFRIES. *Paper at March 1930 Detroit Automotive Symposium, American Society for Testing Materials; Iron Age*, March 27, 1930, Vol. 125, pages 918–920.
Lists the automobile parts in which aluminum alloys can be effectively utilized. The combination of an alloy high in silicon which has a low coefficient of expansion, for an aluminum alloy, used as a piston against a cast iron containing about 20% monel metal plus manganese and chromium, which has a high coefficient of expansion, allows the use of aluminum pistons without split skirts or invar struts. Large use of aluminum decreases weight and improves performance. The maximum feasible use of aluminum would increase the material cost of a medium sized car by $100. HWG(9)

Nickel Developments during the Past Twenty-one Years. W. T. GRIFFITHS. *Metal Industry*, London, Jan. 17, 1930, Vol. 36, pages 77–80.
Discusses the uses of pure nickel in coinage, chemical engineering, nickel plating and radio engineering. Outlines briefly the applications of the more important alloys of nickel. VSP(9)

Some Applications of Aluminium. EDGAR T. PAINTON. *Metal Industry*, London, Jan. 17, 1930, Vol. 36, pages 81–84, 103–104.
Aluminum, in one form or other, is used in nearly every branch of industry. For the various application it is used in 3 forms, pure, casting alloys and wrought alloys. Discusses the various uses to which aluminum and its alloys are now being put. VSP(9)

Metal Wing Ribs are Strong and Light. W. R. R. WINANS. *Iron Age*, Jan. 16, 1930, Vol. 125, pages 230–231.
The Cunningham-Hall Aircraft Corporation of Rochester, N. Y., uses alloy steel tubing for fuselage skeleton. The wing beams and ribs are of duralumin and the cabin is covered with corrugated sheet duralumin. Rigid specifications govern all materials. Physical and chemical reports are required from all sources of supply covering each lot. VSP(9)

Automobile Bearing Metals. C. UPTHEGROVE. *Preprint for March 1930 Automotive Symposium, American Society for Testing Materials*, 14 pages.
Compilation and discussion of previously published investigations by various workers. Useful summary. HWG(9)

Tin and the Alloys of Tin, Lead and Antimony. G. N. NICKLIN, *Metal Industry*, London, Jan. 17, 1930, Vol. 36, pages 67–70, 90.
Includes a brief statistical discussion. Of the various alloys the type metals are perhaps the most important. The composition of type metals varies widely according to the class of work for which the alloys are intended. All ordinary cases are covered by the following range of composition:

tin..... 2 to 12% antimony..... 10 to 30% lead..... the balance

The following limits may be taken as defining the composition in genera' use for each grade of printing metal:

Linotype and intertype metals.
tin..... 2 to 4% antimony..... 10 to 13% lead..... the balance,
Stereotype metal.
tin..... 3 to 10% antimony..... 14 to 17% lead..... the balance
Monotype metal.
tin..... 5 to 12% antimony..... 14 to 25% lead..... the balance
VSP(9)

Metals Used in Aircraft Construction. BRADLEY STOUGHTON. *Metals & Alloys*, Jan. 1930, Vol. 1, pages 317–24; *Chemistry & Industry*, Dec. 13, Vol. 48, 1929, pages 1189–1198. *Chemistry & Industry*, Dec. 13, 1929, Vol. 48, pages 1189–1198.
Aircraft is a contribution of metallurgy. The 3 great enemies with which metals must contend are abrasion, fatigue and corrosion. Table of strength weight factors obtained by dividing ultimate strength in thousands of pounds per square inch by specific gravity is given. Table of analyses of aluminum alloys, heat treatments and physical properties is included. Table of ternary and quaternary alloy U. S. Army aircraft structural steel analyses, properties, heat treatment and uses; table of binary alloy steels and of monel metal, analyses, properties, heat treatment and uses; table of carbon steels, analyses, properties, heat treatments and uses; similar data on aluminum-magnesium alloys; ternary alloy aircraft steels; and, finally, table of analyses of common heat resisting alloys with their respective properties are included. Plots of stress against temperature and reduction of area against temperature for aluminum alloys are given. ESC(9)

Use of Non-Ferrous Metals for Boiler Drums. (Verwendung von Nichteisenmetallen im Dampffassbau.) SCHEFFEL. *Veröffentlichungen des Zentral-Verbandes der Preussischen Dampfkessel-Ueberwachungs-Vereine.* 1929, Vol. V, pages 25–28.
The use of copper, aluminum, nickel and stainless steel for steam boilers is discussed. The strength of Cu drops abruptly at 120° C. For higher temperatures copper vessels should be supported by steel jackets. Cu can be riveted, soldered and gas welded. Al has about half the strength of Cu and is good up to 200° C. It should be at least 99% pure. It can be gas and forge welded. Ni retains its strength up to 300° C. and can be riveted, soldered, gas and forge welded. Stainless steel containing 13 to 25% Cr has higher strength than plain carbon steel and is usually gas welded. It should be annealed after welding by heating to 1200° C. and quenching in water. It should be pickled to obtain stainless qualities. CEM(9)

HEAT TREATMENT (10)

Heat-Treating Aircraft Engine Bearings. J. B. NEALEY. *American Machinist*, Dec. 26, 1929, Vol. 71, pages 1041–1042.
In the manufacture of a spheroidal type of bearing for aircraft engines, the S. K. F. Industries, Inc., uses a Swedish steel that somewhat resembles the S. A. E. 52,100 steel. It has a chromium content of 1.40–1.60%, with a phosphorus maximum of 0.025 and a sulphur maximum of 0.02%. Descriptions of the furnaces used in the heat treatment are given. The steel parts are heated to 1480–1560° F., according to the physical characteristics required. They are drawn at 350° F. which ordinarily gives them a Brinell hardness of 655. The Duralumin is heated at 950–960° F., quenched in water or oil at from 100–210° F. and aged for 48 hours at room temperature. This gives the metal a tensile strength of 62,000 a yield point of 30,000–36,000, an elongation of 18–25% in 2″ and a Brinell Hardness of 93–100. RHP(10)

Hardening (10a)

Tempering Cutting Tools. J. T. TOWLSON. *American Machinist*, Feb. 6, 1930, Vol. 72, page 248.
Though various alloys such as Widia, Carboloy and Stellite are becoming popular for tools in machine shops there are still many who use high speed steel. There is a fixed temperature at which steel of a certain percentage of carbon content should be hardened to secure the best structure for tool steel. As a guide to the purely practical man the following figures are given from the writer's personal experience:

carbon, %	color	max. ° F
1.50	cherry red	1440
1.25	Bright cherry	1485
1.10	Red	1524
1.00	Full red	1575
0.87	Bright red	1620
0.75	Full bright red	1710

For all of these steels the critical point is 1250°F. coming down, and 1300° F. going up. Hammering tool steel when at a black-red heat will not improve its endurance. High-carbon and low-carbon springs are heat treated similarly, except for a difference in the rate of cooling. RHP(10a)

Inherent Hardenability Characteristics of Tool Steel. B. F. SHEPHERD. *Transactions American Society for Steel Treating*, Jan. 1930, Vol. 17, pages 90–110.
Includes discussion. Paper before the Eleventh Annual Convention, American Society for Steel Treating, Cleveland, Sept. 1929. A discussion of the variations of the depth of hardness penetration in carbon tool steels of identical composition. The hardenability of various steels was determined by quenching slabs varying in thickness by steps of $1/32$″ in a special spray. These were then split on a $1/16$″ elastic grinding wheel and etched. The tests seem to indicate that there is a critical thickness of section for each hardenability below which sections that harden through will invariably crack. WHK(10a)

Annealing (10b)

Equipment for Annealing Wire Wheel Hubs. W. M. HEPBURN. *Machinery*, Feb. 1930, Vol. 36, pages 452–453.
Describes the furnaces and processes employed by the Surface Combustion Co. of Toledo, Ohio. The equipment used is of automatic design to simplify the annealing process as much as possible. RHP(10b)

Modern Furnaces for Normalising. *Iron & Coal Trades Review*, Dec. 6, 1929, Vol. 119, pages 865–867.
The "Kathner" furnace is for thin-pack annealing. This method allows a more equal heating than the box method with a consequent similarity of grain size throughout the entire sheet. This is necessary for good deep drawing properties. The furnace is 155 ft. long and has an output of approximately 130 tons. The furnace is in 3 parts: 1. Preheating. 2. Soaking. 3. Cooling. Advantages of thin-pack annealing over box annealing are: 1. No annealing boxes. 2. No balls or ball races. 3. Easy charging. 4. Superior structure of the metal. 5. No sticking. 6. Uniform temperature. 7. Absolute control of heating and cooling temperatures. 8. Sheets finished in 24 hours instead of 2 or 3 days. 9. Sheets only in furnace about 6 minutes. The running cost is about $1.20 per ton. RHP(10b)

Case Hardening and Nitrogen Hardening (10c)

Nitriding Steels. W. H. HATFIELD. *Iron & Coal Trades Review*, Nov. 8, 1929, Vol. 119, page 712.
From a paper entitled, "Steels for Automobiles and Aeroplanes" presented at a joint meeting of the Institution of Automobile Engineers and the Iron and Steel Institute, London, Nov. 5, 1929. See *Metals & Alloys*, Mar. 1930, page 428. RHP(10c)

Property Changes of Iron-Nitrogen Alloys by Quenching and Drawing Below A_1. (Ueber die Eigenschaftsänderungen der Eisen-Stickstofflegierungen durch Abschrecken und Anlassen unterhalb A_1.) W. KÖSTER. *Archiv für Eisenhüttenwesen*, Feb. 1930, Vol. 3, pages 553–558; *Stahl und Eisen*, Feb. 27, 1930, Vol. 50, pages 254–255.
Electrolytic iron and steel with 0.1% and 0.2% C were nitrided to study the influence of various heat treatments on the solubility of nitrogen in α-iron. α-iron dissolves nitrogen in solid solution to .5% at 580° C. (eutectoid transformation) and .015% at room temperature. Fe_4N is precipitated along this line of segregation (separation). The supersaturated solution of Fe_4N in α-iron, obtained by quenching, is very brittle. The solid solution can be decomposed by drawing, 1 hour at 150° C. is necessary to accomplish this effect. The solution Fe_4N shows an aging effect like Duralumin. An alloy with 0.12% N originally had a Brinell hardness of 105, after quenching from 550° C. 190 and after a 28 day aging at room temperature hardness of 270. A_1 in carbon steels is lowered by nitrogen. Magnetic investigations result in the statement that shape and distribution of nitrides are of immense importance for magnetic properties. Coercive force is increased considerably by finely distributed nitrides, originating from segregation of the solid solution. Solubility of N in α-Fe increases between 100–150° C. Fe_4N shows little inclination to spherodize. Fry's agent is especially qualified to detect nitrogen and its distribution in a sample. GN(10c)

JOINING OF METALS AND ALLOYS (11)

Soldering (11b)

What Price Solder? C. J. ELLIOTT. *Industrial Engineering*, March 1930, Vol. 88, pages 120–121.
Based on tests with 8 standard grades of solders, meeting A. S. T. M. specifications, the author states that the application of more expensive solders is frequently more economical than the use of the cheaper ones. GN(11b)

Welding and Cutting (11c)

Arc Welded Jigs, Fixtures and Machine Tools. J. R. WEAVER. *Journal American Welding Society*, Feb. 1930, Vol. 9, pages 7–18; *Machinery*, March 1930, Vol. 36, pages 532–535.
General discussion. To fix responsibility for poor welding, all welders in the author's shop are required to stamp the product so it can be identified as their work. HWG&RHP(11c)

Inspection of Welds and Selection of Welders. C. C. WATSON. *American Welding Society Journal*, April 1930, Vol. 9, pages 137–140.
Welders for bridge or building work should be tested before employment. Suggested tests are described. HWG (11c)

The Theory of Stresses in Welds. L. C. BIBBER. *American Welding Society Journal*, April 1930, Vol. 9, pages 104–137.
Deals with fillet welds. HWG (11c)

Preheating Practices. A. G. WIKOFF. *American Welding Society Journal*, April 1930, Vol. 9, pages 87–103.
Profusely illustrated account of methods and devices used for preheating before welding. HWG (11c)

The Calorimetric Study of the Arc. P. P. Alexander. *Journal American Welding Society*, Feb. 1930, Vol. 9, pages 25–32.

Study of the iron welding arc, also iron-graphite and graphite-graphite. The amount of energy developed at anode and cathode are practically equal. Differences in the rate of melting depend on position of the electrode, and the direction of the blast of hot gases evolved from each electrode. Experimental details are given. HWG(11c)

Cutting Steel Shapes with the Oxy-Acetylene Torch. F. E. Rogers. *Journal American Welding Society*, Feb. 1930, Vol. 9, pages 44–54; *Machinery*, Mar. 1930, Vol. 36, pages 554–556.

Description of mechanically operated torch cutting devices and methods. HWG&RHP(11c)

Design and Fabrication of Oxy-Acetylene Welded Buildings. H. M. Priest. *Journal American Welding Society*, Feb. 1930, Vol. 9, pages 33–43.

Structural details. HWG(11c)

Recommended Procedure for Fusion Welding of Pressure Vessels. American Society of Mechanical Engineers, Boiler Code Committee. *Journal American Welding Society*, Feb. 1930, Vol. 9, pages 67–76.

Requirements as to materials, design, construction, qualification of welders, supervision, inspection and testing. HWG(11c)

Structural Steel Welding. F. P. McKibben. *Metals & Alloys*, Jan. 1930, Vol. 1, page 328; *General Electric Review*, Vol. 32, Nov., 1929, pages 622-625; *American Metal Market*, Vol. 36, Nov. 7, 1929, page 7.

Over 75 bridges or buildings have recently been completely or partially structurally welded. Many cities are revising their building codes to permit welding. Tests methods are not satisfactorily developed. Welded plated girders are 15.2% lighter than riveted girders. Skill of workmen should be determined for this work. ESC&WHB(11c)

Resistance Welding. B. T. Mottinger. *Journal American Welding Society*, Feb. 1930, Vol. 9, pages 54–66.

Discussion of flash butt welding, spot welding and seam welding. The low power factor of butt welders is not objectionable. In Detroit, a welding machine load is as welcome to the power company as any other. Micrographs of all 3 types of welds are given. HWG(11c)

An Investigation of Welded Connections Between Beams and Columns. E. H. Uhler & C. D. Jensen. *American Welding Society Journal*, April 1930, Vol. 9, pages 61–87.

Account of tests and discussion of engineering principles involved. All the web-welded joints were indicated to be dangerous. Flange-welded connections with reinforcing plates can be made as strong as the beam. In short-beam tests the web joints appeared better than in long-beam tests, but are viewed with suspicion. HWG (11c)

The Repair of Steel Bridges by Electric Arc Welding. C. M. Taylor. *Engineering and Contracting*, Feb. 1930, Vol. LXIX, pages 63–65.

Some examples of the reinforcement of trusses and girders by means of the electric arc. GN(11c)

Arc-Welded Steel Roofs. A. F. Davis. *Journal American Welding Society*, March 1930, Vol. 9, pages 54–56.

Structural details. HWG(11c)

Strengthening Bridges and Structures by Welding. A. G. Leake. *Journal American Welding Society*, Feb. 1930, Vol. 9, pages 18–25.

Discussion of repair work. HWG(11c)

Cathode Energy of the Iron Arc. G. E. Doan. *Journal American Welding Society*, March 1930, Vol. 9, pages 9–14.

Mathematical discussion. HWG(11c)

Welding Stainless Steel and Monel Metal. M. E. Olsen. *Journal American Welding Society*, March 1930, Vol. 9, pages 25–32.

In fabrication of equipment from stainless alloys for handling milk and milk products, a smooth interior is required, free from cracks and crevices. Oxy-acetylene, electric arc and spot welding and soldering are used. The material most used is 18% Cr 8% Ni austenitic steel. With this or monel, seam welding is done without the weaving motion common in steel welding. Arc welding is used more than oxy-acetylene because of better control. Soldering does not give the required strength, but gives a good finish, so many jobs are tack welded for strength, and soldered for finish. There is nothing especially mysterious or difficult about the welding of these materials. HWG(11c)

Application of Arc Welding to Machine Design and Building Construction. A. M. Candy. *Journal American Welding Society*, March 1930, Vol. 9, pages 66–73.

Comments on advantages of welding and on value of altering design so that the welding process will be suitable and save weight. The author states, "Castings for machinery are rapidly becoming obsolete except for small complicated parts or small simple parts of very large production." This is based on a comparison of the properties of cast iron and wrought steel, on the large reduction in weight usually possible, and on the smaller investment in welding equipment as compared with that in a foundry. HWG(11c)

Careful Design is Necessary in Airplane Welding. Kendal Perkins. *Iron Trade Review*, Feb. 6, 1930, Vol. 86, pages 77–78, 80. Condensed in *Metal Stampings*, Jan. 1930, Vol. 3, pages 67–68.

Paper read before International Acetylene Association, Nov. 13–15, 1929. In designing welded joints of Cr-Mo tubing, maximum efficiency can be obtained only by strict observance of the following fundamental considerations: (1) welded Cr-Mo steel becomes harder and stronger next to the joint, but softer and weaker a short distance away; (2) the "critical section" must be kept outside of the joint proper, the "critical section" being defined as that sectional surface through which a joint will break when subjected to sufficient stress applied in a normal manner. MS(11c)

Selecting the Type of Welding for the Job. T. H. Booth. *American Machinist*, Jan. 9, 1930, Vol. 72, pages 47–49.

Five types of welding are discussed. 1. Oxy-acetylene. 2. Alternating-current arc. 3. Direct-current arc. 4. Spot. 5. Butt welding. Suggests types of work where each of these are suitable and methods of using each. RHP(11c)

Butt Welding Improves Copper Wire Drawing. C. R. Hoffman. *Electrical World*, March 22, 1930, Vol. 95, pages 591–592.

The drawing of copper wire can now be made continuous, except for the replacement of dies, by the use of a recently developed butt welder by joining the ends of toe rod stock. The combination of intense heat and high pressure forces the copper rods together in about 1/10 second. The welding is illustrated. The average tensile strength of the welded joint on rod samples was 97% of the rod stock, and satisfactory welds are 95–99% in nearly 16,000 joints. WHB(11c)

The Role of Atomic Hydrogen in Welding. S. Martin, Jr. *American Machinist*, Feb. 13, 1930, Vol. 72, pages 301–304.

With an atomic-hydrogen flame a maximum temperature of about 4000° C. may be obtained. It gives a highly reducing atmosphere. In general all varieties of steel including alloys with nickel, chromium, manganese and molybdenum, are readily weldable. Atomic-hydrogen welding does not replace metallic-arc welding but makes possible the welding of steel sheets down to the thickness of the wafer razor blade. Cast steel and steel with a carbon content as high as 1.25% have been welded by this method. Chromium steels up to 40% chromium may be welded but give a brittle weld. Heat treatment will reduce the brittleness if the chromium content is below 20%. Alloys other than steel can be welded. Zinc and copper present more difficulty but alloys of these in some percentages, and with the proper fluxes, may be welded. Gives a summarized table and chart of data for atomic hydrogen welding. RHP(11c)

Airplane Welding Done in Jigs. Charles O. Herb. *Machinery*, Jan. 1930, Vol. 36, pages 372–375.

To obtain the maximum strength and rigidity, combined with minimum weight, the Fairchild Airplane Manufacturing Corporation, Farmingdale, Long Island, N. Y., uses chrome-molybdenum steel tubing almost exclusively in construction of the framework of the fuselages, ailerons, stabilizers, elevators and rudders. Describes methods and mechanical aids used in welding these parts. RHP(11c)

Welding and Cutting. *American Machinist*, Feb. 6, 1930, Vol. 72, page 275.

Lists the nomenclature and gives definitions of the processes of welding and cutting. Covers the fields of forge-welding, pressure-welding and fusion welding. RHP(11c)

Welded Weapons—New Processes Applied to the Manufacture of Ordnance. J. B. Rose. *Army Ordnance*, March-April 1930, Vol. X, pages 305–310.

The application of welding to a number of ordnance structures is illustrated. (11c)

Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers. A. S. M. E. Boiler Code Committee. *American Welding Society Journal*, March 1930, Vol. 9, pages 57–61.

Presented for criticism and comment. Annealing for stress release at at least 1100° F., holding for one hour per inch of thickness is stipulated. Tension, bend and impact tests are required. Charpy impact, standard A. S. S. T. bar, to be 20 ft.-lbs. minimum. Nitrogen content of weld specified not over 0.02%. Macrographs and micrographs required. Non-destructive tests, as X-ray or electrical fissure detector suggested. Most commenters to date consider these stipulations, from nitrogen content on, unnecessary. The annealed vessel is to be subjected to 10,000 cycles of pressure from 0 to 1½ working pressure, and non-destructive test again to be applied (objections are raised to this by commenters). Maximum working stress to be 16% of the minimum specified tensile strength of the plate used (criticisms are stated to claim that 90–100% should be allowed). HWG(11c)

Four Years Experience with Structural Welding. A. L. Wilson. *American Welding Society Journal*, March 1930, Vol. 9, pages 38–53.

Deals with design changes necessary to allow satisfactory welding. Many shop kinks are given. Automatic welding is suitable for much work. Galvanized steel can be satisfactorily welded. HWG(11c)

Large Scale Ornamental Work. D. & E. Endicott. *American Welding Society Journal*, March 1930, Vol. 9, pages 33–37.

Illustrations of architectural decorative work. No technical details. HWG(11c)

Arc Welding of Structural Steel. J. J. Wallace. *American Welding Society Journal*, March 1930, Vol. 9, pages 61–66.

Brief discussion of advantages. HWG(11c)

Resistance Seam Welding in 1929. W. H. Gibb. *American Welding Society Journal*, March 1930, Vol. 9, pages 32–33.

Résumé of recent developments. Welding of terne plate, various non-ferrous metals and corrosion-resistant steels became common in 1929. Special automatic machines were developed. The current interrupter has speeded up seam welding. HWG(11c)

Electrically Welded Structures Under Dynamic Stress. M. Stone & J. G. Ritter. *American Welding Society Journal*, March 1930, Vol. 9, pages 15–24; *Journal American Institute of Electrical Engineers*, March 1930, Vol. 49, pages 203-205.

Contrasted with endurance limits of ± 25,000 lbs./in.² for mild carbon steel and up to ± 60,000 for some alloy steels, the endurance limit of weld metal varies from ± 9,000 to ± 22,000 depending largely on the care taken in welding. With good welding practice one may take the endurance limit of weld metal as ± 15,000 lbs./in.² For static stress the yield point value may be taken as 30,000 lbs./in.² In Westinghouse design, a factor of safety of 3 is applied to either endurance limit or yield point, so that allowable stress are 5,000 lbs./in.² for reversed, repeated stress and 10,000 for static stress. Applications are discussed in which repeated stress is superimposed on static stress. The Goodman diagram is preferred to the Gerber for variable stress. The fatigue stress of welded joints cannot be increased by using high grade parent metal, as the welding heat reduces the endurance limit to or below that of mild structural steel. For example, if a ring of metal is welded around a bar of heat-treated nickel chromium steel of ± 66,000 lbs./in.² endurance limit and all the weld metal machined off, the bar then has an endurance limit of about ± 16,000 lbs./in.² Welded assemblies may be much weaker in fatigue than one would expect from the test of a simple weld, due to the internal stresses set up by shrinkage of weld metal and unequal heating of the structure. Annealing at 1000° F. is adopted to release internal stress. Higher annealing temperatures introduce danger of warping and cracking the welds. In spite of the limitations of welded structures for use under repeated stress, if welding practice is good, and the design is made with the proper factor of safety, welding may be satisfactorily used. Welded rotors, blower-propellers, turbine blade lashings, gear cases, etc. properly designed with consideration of actual working stress, residual welding stresses and stress concentration are giving entire satisfaction. HWG(11c)

Nation Wide Welded Steel Noiseless Building Service. *The Glass Industry*, March 1930, Vol. 11, page 68.

News note briefly recounting the announcement of a new welded construction method by the Austin Company of Cleveland. WHK(11c)

Some Recent Developments in Arc Welding. K. L. Hansen. *Iron & Steel Engineer*, March 1930, Vol. 7, pages 113–118.

Includes discussion. Paper at Electric Heating Conference at Penn State, November, 1929. A review of the progress of electric arc welding in building, pipe line, track construction, etc. Hard surfacing, the welding of stainless (Ni-Cr) steels, and of non-ferrous materials are taken up. WHK(11c)

Investigations of Welded Connections of Aluminum Steels. (Untersuchungen von Schweissverbindungen an Aluminium-stählen.) Christmann. *Veröffentlichungen des Zentral- Verbandes der Preussischen Dampfkessel-Ueberwachungs- Vereine*, 1929, Vol. VI, pages 71–73.

Attempts to weld steel of the composition C .09, Cr 6.90, Mo. 39, Al 1.88 to 2.75 with wire of the same composition resulted in very porous welds. Welding wire with C .14, Cr 18.41, Ni 8.94 and C .07, Cr 26.46, Ni 20.12 produced very good, tight joints. Illustrated with macro-and micro-photographs. CEM(11c)

Method of Testing Welding Seams. (Prüfverfahren für Schweissnähte.) W. Zimm. *Veröffentlichungen des Zentral- Verbandes der Preussischen Dampfkessel-Ueberwachungs- Vereine*, 1929, Vol. V, pages 17–22.

Tensile tests and X-ray examination of welds can be carried out in a laboratory, but not in the shop on the actual work, and require expensive equipment. Bending tests are not reliable as the parent metal usually bends easier than the weld. A ball hardness test can be made by making an impression on the weld with a hammer blow of a 10 mm. diameter ball supported in a holder. For comparison an impression is also made on the parent metal, whose Brinell hardness is known. By measuring the diameter of the two impressions the Brinell hardness and tensile strength of the weld are calculated. A comparison of a number of ball tests and actual tensile tests show fairly good agreement. The ductility is measured by making a ball impression, and bending until the weld cracks. The impression is now shaped like an ellipse and the two diameters are measured. The ductility equals $\left(\frac{D}{d} - 1\right) \times 100$. Macroscopic examination, magnetic testing and a portable X-ray machine are described. CEM(11c)

WORKING OF METALS AND ALLOYS (12)

Melting and Refining (12a)

White Metals, Brass and Bronzes. Part 4. E. PERRY. *Metal Industry* (N. Y.), Feb. 1930, Vol. 28, pages 70–71.

In making a mix for brass, bronze, babbitt and white metals, it is important that each material is weighed accurately. The order of charging the metals in the crucible is as follows: charge the high melting alloys first; follow with the non-volatile low melting point metals: and when these are melted add the volatile metals. There are exceptions to the above order, but in general it may be followed with safety. In routine brass making scrap mixtures are used. These must be freed from oxides and other impurities to insure sound castings. VSP(12a)

Copper Oxide Eliminates Aluminum. J. H. CHEETHAM. *Foundry*, Feb. 1, 1930, Vol. 58, page 99.

Discusses results of tests conducted on metals contaminated with aluminum. Tests showed that by using copper oxide to eliminate aluminum very good results were obtained. VSP(12a)

The "Musso" Steel-Making Process. *Iron & Coal Trades Review*, Dec. 13, 1929, Vol. 119, page 916.

The process is carried out in 2 parts. 1. Ore is reduced in a rotary retort. 2. The product is converted into steel. Low grade coal or lignite is mixed with iron ore and charged into the rotary retort. Heat is applied externally till the retort is sealed. The gases are exhausted and thereafter furnish the fuel for the operation. The rotary motion of the retort makes the transfer of heat rapid and even. Magnetic separators and fluxes are used to separate the materials. The iron as tapped from the furnace contains less than 1% of impurity. The iron is then discharged into a steel making furnace. Other ingredients are added in proportions such as will give steel of the desired specification. This process is claimed to produce metal equal to high-grade electric steel and is 20% cheaper than the methods used in Canada at the present time. RHP(12a)

Comments on Production of Electric Steel for Casting. R. A. BULL. *Foundry*, Feb. 15, 1930, Vol. 58, pages 103–104.

Compiled from a discussion of George Batty's article "Production of Electric Steel for Castings and read before the American Society for Steel Treating, Sept. 9–13, 1929. See *Metals & Alloys*, Jan. 1930, Vol. 1, page 344. VSP(12a)

Investigations on the Reactions of Manganese and Phosphorus in the Basic Open Hearth Process. (Untersuchungen über den Verlauf der Mangan-und Phosphor-reaktionen bei den basischen Stahlerzeugungsverfahren.) H. SCHENCK. *Archiv für Eisenhüttenwesen*, Feb. 1930, pages 505–530, Vol. 3; *Krupp'sche Monatshefte*, Jan. 1930, Vol. 11, pages 1–28; Feb.-Mar. 1930, pages 29-38.

After considering principally the meaning of a state of equilibrium for metallurgical processes, the theoretical basis for the examined reactions are developed. By examining 14 samples and temperatures of open hearth melts and 4 melts of basic Bessemer steel the conditions of equilibrium are calculated for the following reactions: (1) concentration of CaO bound to P_2O_5, (2) concentration of CaO bound to SiO_2, (3) concentration of free CaO and free FeO in the slag, (4) equilibrium of the reactions of Mn, and (5) equilibrium of the reactions of phosphorus. The laws derived are checked with the test results and tabulated in tables and diagrams. The influence of composition and temperature of slag on the course of reactions is discussed. The article concludes with considerations on the possibility of obtaining equilibrium in the practice. Herty's law for the equilibrium of manganese is checked. GN(12a)

Making Steels for Locomotive Forgings. L. H. FRY. *Railway Mechanical Engineer*, Feb. 1930, Vol. 104, pages 72–74.

Factors in melting, pouring and cooling which affect the quality of steel are considered. GN(12a)

The Slags Produced in Steel Making—Their Effects on the Product and on the Process Itself. GEORGE A. DORNIN. *Transactions, American Society for Steel Treating*, Jan. 1930, Vol. 17, pages 59–80; *Iron and Coal Trades Review*, Oct. 18, 1929, Vol. 119, page 577.

Includes discussion. Paper before the Eleventh Annual Convention, American Society for Steel Treating, Cleveland, Sept. 1929. The author considers the possibility of changing the slag so as to finish the heat under a non-oxidizing slag, i. e., one of low FeO content. This can be done fairly easily in the electric furnace, finishing under a CaC_2 slag, but the cost of this process is high and the field very limited. The greatest need for a 2 slag method is in the basic open hearth process upon which we are dependent for the major part of our steel supply. Considerable discussion follows this paper upon the feasibility of changing slags upon large furnaces (possibly by the use of 2 or more furnaces) and upon the proper methods of adding deoxidizers. WHK & RHP(12a)

Forging (12d)

Development of Upset Forgings. WILLIAM E. CROCOMBE. *Iron Age*, Dec. 5, 1929, Vol. 124, pages 1513–1515.

Upset forging, a new process of forging used in making automotive forgings, rivets, bolts, nuts and miscellaneous railroad car forgings. This method eliminates tong holds. Recent improvements in upset forgings include the production or irregular designs requiring a trimming operation to remove flash, and which is generally finished in the same die. Uniform grain conditions give higher strength and increased density, eliminating warpage in heat treating. Plea for adequate cost analysis. VSP (12d)

Nickel and Monel Metal. *American Machinist*, Feb. 27, 1930, Vol. 72, page 385.

Monel metal must be forged at temperatures between 1850 and 2100° F. Nickel must be forged between 1850 and 2200° F. The time required will vary from 20 minutes to an hour depending on the size of the rod or billet. The metal should not be held in the furnace after it reaches the proper temperature as any sulphur in the flame will react with the metal. These metals should not be forged or bent at red heat as they are distinctly "red short" between 1200 and 1800° F. The condition being worst at 1400° F. RHP(12d)

Machining (12g)

Welded-On Overlays in Machine Design. MILES C. SMITH. *American Machinist*, Feb. 6, 1930, Vol. 72, pages 265–267.

Welded-on overlays have not been used to any extent. Their chief use to date has been in oil field drilling equipment. Tungsten carbide and similar materials may be welded to the parent metal giving it a great surface hardness without heat treatment. An overlay of tungsten carbide is smelted in the open air at a temperature of about 6000° F. and if properly applied will be completely fused to the parent metal. Due to the high melting point of tungsten, which is over 6000° F. ordinary heats caused by friction other heat producing agencies do not affect it. Metallic alloys used as overlays are: wear resistant, largely corrosion resistant, and have a low coefficient of friction. RHP(12g)

Uses of Cemented Tungsten Carbide Extend beyond Expectations. T. GESCHELIN. *Automotive Industries*, Feb. 15, 1930, Vol. 62, pages 227–228.

A review of the factors affecting the application of cemented-tungsten-carbide tools. The machine tool must primarily be given consideration. GN(12g)

Tungsten Carbide. *American Machinist*, Feb. 20, 1930, Vol. 72, page 349.

Tungsten carbide is manufactured under a variety of trade names and in slightly varying compositions. A general analysis is: Carbon, 3–6%; tungsten, 80–95%; cobalt, up to 13%. Cobalt is added for physical strength. The Brinell hardness number of tungsten carbide is 2000 to 2500. Due to its extreme hardness it will cut materials which tool steel cannot touch. Higher cutting speeds are possible than with tool steel. RHP(12g)

Drawing and Stamping (12h)

Success of Deep Drawing Operations of Strip and Sheet Steel Depends upon Microstructure. I. WINLOCK & G. L. KELLY. *Automotive Industries*, Feb. 15, 1930, Vol. 62, pages 220–223.

The paper discusses the granular structure of sheets, the effects of grain size upon deep drawing properties and how grain size may be controlled in the rolling mill as well as in the drawing plant. GN(12h)

Drawing Chrome-Nickel Alloy Utensils. *Iron Age*, Feb. 6, 1930, Vol. 125 pages 445–446.

Number of culinary equipment makers use high chrome-nickel alloy. The Lalance & Grosjean Mfg. Co. uses alloy made by Allegheny Steel Co., with an analysis of 17–20% chromium, 7–10% nickel, carbon under 0.20%, manganese under 0.50%, silicon under 0.50% and phosphorus under 0.25%. White pickled sheet is used for drawing, as a polished surface would be removed by drawing and annealing. In heat treating the alloy is subjected to 1900–1950° F. for about 3¼ minutes depending on thickness of the section. After the final draw the utensil is annealed again. Special care is required in processing. VSP(12h)

Influence of Dies and Drawing Practice on Quality of Wire. H. C. JENNISON. *Rolling Mill Journal*, Feb. 1930, Vol. 4, pages 55–58.

From paper read before American Institute of Mining & Metallurgical Engineers, Feb. 17–30. Check marks on surface of Cu wire are caused by improper die design. A die of great angularity at drawing bell with a short bearing or no bearing at all will cause check marks rapidly. If the drawing surfaces are not smooth due to blow-holes plugging with scale, etc. surface tears and check marks will occur. Cuppy wire will result if the angularity of the die is too great and the draft on the wire is too light. It can also be produced by drafting the wire machine too tightly, even with dies of satisfactory design. A die with a 15° drawing bell and a 5° bearing has been found very satisfactory. MS(12h)

Sheet Steels for Automobiles. W. H. GRAVES. *Preprint for March 1930 Automotive Symposium, American Society for Testing Materials*, 8 pages.

Suitability of deep-drawing steel for making body panels and fenders is more definitely shown by laboratory tests than by actual use. If the tests show the steel to be O.K., and it does not behave well in the press, the trouble is due to the setting of the press. Rockwell and Erichsen tests are sufficient. If steel meets the laboratory tests, the Packard Company stands all scrap in production. For 18 and 19 gage steel, S.A.E. 1010, the specified Rockwell range is 43 to 53, B scale. (In discussion 50 was suggested as a safer maximum.) For ordinary deep-drawing steel a minimum Erichsen value of 10.5 and for extra-deep-drawing, of 11, is specified. No comment is made on the modification of the Erichsen test being tried out abroad in which a hole is punched in the specimen and the cracking of the specimen at the hole taken as a criterion of failure. HWG(12h)

Pickling (12i)

Metal Pickling. *American Machinist*, Feb. 13, 1930, Vol. 72, page 313.

Some of the principles of metal pickling are: 1. Steam and air as aids to scale removal are cheaper than acids. 2. A fresh solution will pickle clean, and an old solution will leave stains. 3. With almost no exceptions, the fastest pickling is the best pickling. Some good rules of practice include: 1. Use a pickling machine that will raise and lower the piece steadily at from 20–30 strokes/min. 2. Work baths at high temperatures, 180–190° F. in fresh baths of acid and up to boiling point in an old bath. 3. Use short-time pickling to avoid embrittlement and pickle blistering. 4. Use 2 tanks to assure clean pickling. 5. The acid concentration should be the minimum required to clean the sample, at the temperature, and within the time allowed. Good conditions for most sheets may be taken as: temperature, 180° F.; bath, 3 minutes in each of 2 tanks; concentration 3% sulphuric acid; limiting gravity of the old bath, 20° Baumé. 6. Use a good inhibitor. RHP(12i)

Pickling for Vitreous Enamel. C. D. CLAWSON. *American Machinist*, Feb. 13, 1930, Vol. 72, pages 295–297.

Good pickling is essential to successful enameling. In general the operation consists of cleaning the parts of oil and grease, pickling them to remove the scale, washing and neutralizing of the remaining acid. Oil removal is best done by boiling in water and an oil removing compound. For picklings either muriatic or sulphuric acid may be used. If sulphuric acid is used its strength should be 7%, temperature 150° F., and time of immersion 10 minutes. Gives figures for the amount of material which may be cleaned and pickled in a certain size bath and the amounts which must be added to keep the solution up to efficient working strength. Discusses the frequency necessary in changing the solutions. Steam is the usual source of heat for the tanks. Points to watch in the operations are: 1. Cleaning tank must be kept at proper strength and temperature. 2. Scum should be removed from the cleaning tank as fast as it appears at the surface. 3. Rinse tanks should have a constant source of fresh water and an overflow. 4. Acid tanks should be kept at the proper strength and temperature and renewed promptly at the proper time. 5. The operator should keep a constant check of the time required, and the results of the cleaning. RHP(12i)

Longer-Lived Equipment for Metal Pickling. C. A. CRAWFORD. *American Machinist*, Jan. 9, 1930, Vol. 72, pages 58–61.

Pickling tanks are often given a lead lining to prevent corrosion. The chains and rails of conveyor equipment are subject to much corrosion due to the action of the fumes from the pickling baths. This may be overcome by the use of monel metal or by use of some of the corrosion resistant steels on the market. Hoods should also be made of corrosion resistant material. When pickling cold-rolled steel for subsequent case hardening any chain containing copper cannot be used as minute deposits of copper will give soft spots in the case. A pure nickel chain may be used for this operation. These corrosion resistant materials are higher in original, but lower in final cost due to longer life. RHP(12i)

Some Practical Features of Wire Pickling. W. G. IMHOFF. *Wire & Wire Products*, March 1930, Vol. 5, pages 77–80, 94–95.

The article gives a general outline of basic principles in wire pickling and deals with conditions to be observed in the process. GN(12i)

Cold Working (12j)

Press Working and Forming of Metals. Pt. XXI. Control of Crystalline Structure and Surface of Drawn Metals. E. V. Crane. *Metal Stampings*, Feb. 1930, Vol. 3, pages 129–134, 169–170.

A number of factors affect the annealing of cold worked metals. Severely cold worked metal can be completely re-annealed at a lower temperature than that only slightly strained. The rate at which metal strain hardens in cold working is less rapid as the working temperature approaches that of recrystallization. Strain hardening in the cold work range is cumulative. Presence of impurities and alloying elements in pure metals tends to increase annealing temperature and frequency of annealing. Coil stock is better for drawing than sheet or strip, as the latter is usually annealed in large packs requiring relatively long heating at low temperatures with non-uniform results. The longer the anneal at a given temperature the greater is the average grain size, with the possibility of non-uniform excessive grain growth. Rapid annealing results in a uniform structure. A high temperature for the same length of time will result in larger grains. The temperature at which excessive grain growth results is lower for more severely cold worked material than for that less severely worked. The distinctly different markings on the outer surface indicate what has been done to drawn shells. A burnished surface indicates ironing. Alternately polished and drawn vertical bands indicate formation of wrinkles which have been partially ironed out. Excessive cold working between anneals is indicated by vertical cracks. A pebbled surface may be caused by twisting of groups of crystals through slip plane movements. Alligator skin markings are due to deformation by slip in certain favorably oriented grains. MS(12j)

Investigation of Strength and Structure of Cold-Rolled and Annealed Strip Steel with Different Heat Treatments. (Festigkeits und Gefügeuntersuchungen an kaltgewalzten und gegluehten Bandstaehlen verschiedener Vorbehandlung.) A. Pomp & H. Poellein. *Archiv für das Eisenhüttenwesen*, Sept. 1929, Vol. 3, pages 223–231.

Influence of cold rolling with different pressure distributions and number of passes on strain hardening (tensile strength, elongation and hardness) and on structure of strip steel of increasing carbon content and of different structures; influence of annealing; practical conclusions. See *Metals & Alloys* Feb. 1930, page 383. GN(12j)

Polishing and Grinding (12l)

Fixed Method Preferred to Free Hand Operations in Grinding Cemented-Tungsten Carbide Tools. H. W. Wagner. *Automotive Industries*, March 1, 1930, Vol. 62, pages 370–373.

Methods of grinding cemented tungsten carbide tools are dealt with in detail. See *Metals & Alloys*, March 1930, page 430, "Grinding of Cemented Tungsten Carbide." GN(12l)

Polishing Stainless Steels T. C. Eichstaedt. *Metal Industry*, (N. Y.) Feb. 1930, Vol. 28, page 73.

Due to increase in the use of rustless chrom-iron alloys it has been necessary to develop new methods of polishing and buffing. Few of the essential points are: polishing speeds up to 10,000 ft./min. High quality hide glue and Turkish emery are necessary to produce bests results. Polishing and buffing wheels must be kept clean and cannot be used to polish any other metal or alloy. Automatic polishing machines have greatly increased progress. VSP(12l)

CHEMICAL ANALYSIS (14)

Determination of Manganese in Steel and Iron by the Persulphate-Arsenite Method. H. A. Bright & C. P. Larrabee. *Bureau of Standards Journal of Research*, Oct. 1929, Vol. 3, pages 573–580.

The advantage of using phosphoric acid in the persulphate-arsenite method and the effect of certain dissolved salts on the titration of permanganic acid by sodium arsenite are discussed. A description is given of the persulphate-arsenite method as used at the Bureau of Standards. In the recommended procedure, which embodies no new principles, as much as 20 mg. of manganese can be handled. It is, therefore, possible to use 1 g. samples in practically all cases. The results obtained by this procedure are much better than those obtained on smaller samples by the ordinary persulphate method and are practically of the same order of accuracy as obtained by the standard and much more elaborate bismuthate method. (14)

Ceric Sulfate as a Volumetric Oxidizing Agent. X. The Determination of Thallium. H. H. Willard & Philena Young. *Journal American Chemical Society*, Vol. 52, January 1930, pages 36–42.

Thallium may be rapidly and accurately determined by titration of thalous salt in HCl solution with standard ceric sulfate. MEH(14)

The Use of Potentiometric Volumetric Analysis in the Steel Mill Laboratory, Especially for the Determination of Manganese, Chromium and Vanadium when Present Simultaneously. (Die Anwendung der potentiometrischen massanalyse in Eisenhüttenlaboratorium, insbesondere zur Bestimmung von Mangan, Chrom und Vanadin nebeneinander.) P. Dickens & G. Thanheiser. *Archiv für Eisenhüttenwesen*, Oct. 1929, Vol. 3, pages 277–290.

The methods of potentiometric titration used are described and their advantages over the usual volumetric methods are indicated. A method is given for determining Mn, Cr and V when present in steels, with and without W, and a simple apparatus for this is described. Numerous literature references are given. (14)

The Quantitative Determination of Osmium by Means of Strychnine Sulfate. S. C. Osburn Jr., & L. F. Miller. *Journal American Chemical Society*, Jan. 1930, Vol. 52, pages 42–48.

Strychnine sulfate reacts with all of the platinum metals to form precipitates, but the precipitate formed with ruthenium is soluble in boiling ethyl alcohol, from which it does not separate easily on cooling even after several days. Osmium may be separated from ruthenium since the former compound precipitates completely on cooling the alcoholic solution. MEH(14)

A Reductor Apparatus for Detecting Tin. J. H. Reedy. *Industrial & Engineering Chemistry, Analytical Edition*, Jan. 15, 1930, Vol. 2, pages 117–118.

Lead is used in the reductor tube. Zinc and aluminum, as well as iron used as reductants have proved unsatisfactory. Lead reduces the tin to the required valence, and is practially unattacked by dilute acids. Discussion of interfering ions is included. MEH(14)

Use of Protective Colloids in Colorimetric Determination of Certain Metals as Lakes of Dyes. Walter E. Thrun. *Industrial & Engineering Chemistry, Analytical Edition*, Jan. 15, 1930, Vol. 2, pages 8–9.

Attention is called to the value of gum arabic and of starch glycerite as protective colloids for dilute lake solutions, containing aluminum, beryllium or magnesium. MEH(14)

Determination of Carbon in High-Melting Alloys Using the High-Frequency Induction Furnace. G. Frederick Smith & G. L. Hockenyos. *Industrial & Engineering Chemistry, Analytical Edition*, Jan. 15, 1930, Vol. 2, pages 36–38.

High-speed tungsten steels, stainless steels of high chromium content, lium, stellite metal, etc., have been subjected to the high-frequency induction furnace, and the carbon content determined. The results seem to be very satisfactory. MEH(14)

Determination of Cobalt in Driers, Japans and Alloys. Oscar Heim. *Industrial & Engineering Chemistry, Analytical Edition*, Jan. 15, 1930. Vol. 2, page 38.

The method of Vogel, made quantitative, is described and has been tested, Cobalt up to about 20% has been determined satisfactorily. MEH(14)

Estimation of the Volatile Wood Acids Corrosive to Lead Cable Sheath. R. M. Burns & Beverly L. Clarke. *Industrial & Engineering Chemistry, Analytical Edition*, Jan. 15, 1930, Vol. 2, pages 86–88.

The detection of volatile acids in the air drawn from creosoted wood conduit, corrosive to lead cable sheath led to the development of a method for the extraction and estimation of such acids. Acidity data have been obtained for various woods, and correlation is attempted between these acidities and the observed corrosive character of the woods. MEH(14)

Accuracy of the Gutzeit Method for the Determination of Minute Quantities of Arsenic. J. W. Barnes & C. W. Murray. *Industrial & Engineering Chemistry, Analytical Edition*, Jan. 15, 1930, Vol. 2, pages 29–30.

Accuracy is discussed for the Gutzeit method when applied to analyses of portions containing less than 40 micrograms of As_2O_3. The method is not advised for the commercial laboratory. MEH(14)

Rapid Volumetric Method for the Determination of Lead. R. C. Wiley. *Industrial & Engineering Chemistry, Analytical Edition*, Jan. 15, 1930, Vol. 2, pages 124–126.

An accurate and rapid method is described for the determination of lead in alloys which contain in addition antimony and tin. The basis for the method is Alexander's molybdate method. The indicator which is extremely sensitive to small quantities of molybdenum, is made by mixing 10 grams of stannous chloride with 10 grams of potassium thiocyanate and adding 30 cc. of water. The mixture will not be clear and the precipitate will form an excellent background for determining the endpoint. MEH(14)

Perchloric Acid as Oxidizing Agent in the Determination of Chromium. James J. Lichtin. *Industrial & Engineering Chemistry, Analytical Edition*, Jan. 15, 1930, Vol. 2, pages 126–127.

The new method is based on the fact that perchloric acid oxidizes quantitatively chromic salts to chromates. It may also be used for the separation of iron and aluminum from chromium. Accuracy and speed are claimed. MEH(14)

The Application of Spectrographic Methods of Analysis in Steel Plant Laboratories. (Die Anwendung der spektrographischen Analyse im Eisenhüttenlaboratorium.) K. Kellermann. *Archiv für Eisenhüttenwesen*, Sept. 1929, Vol. 3, pages 205–211.

Report no. 66 of the Chemikerausschuss des Vereins deutscher Eisenhüttenleute. The application of spectrographic analysis is briefly considered, and the various methods in use are described. Circuit diagrams for a. c. and d. c. emission spectra are given. The application of solid and liquid samples is discussed and the method of operation is given. See translation in *Metals & Alloys*, April 1930, Vol 1, pages 480–483. (14)

HISTORICAL AND BIOGRAPHICAL (15)

Famous Steel Men and Engineers. No. 3. Robert Forrester Mushet. *Edgar Allen News*, March 1930, Vol. 8, pages 580–582.

The third in a series of articles dealing with men who have built up the steel trade, this time giving a sketch of life of R. F. Mushet. MLM(15)

ECONOMIC (16)

Statistical Compilations on Lead, Copper, Zinc, Tin and Aluminum. *Metallgesellschaft*, Nov. 1929, pages 30–39.

Tables are given showing world production, metal prices and foreign trade for the metals named. MLM(16)

PLANTS & LABORATORIES (17)

Lacquering and Plating in the Laboratories. W. G. Knox. *Bell Laboratories Record*, Dec. 1929, Vol. 8, pages 162–166.

Knox describes the reconstruction and improvement of the Finishing Department of the Bell Laboratories. The new methods give a better control of finishes, particularly of their weight and character. The plating room is considered a model of its type, and a floor diagram is given showing placement of various steps in the plating process. The electrical equipment and various solutions used are described. MLM(17)

The Heddernheim Copper Works. H. von Forster. *Metallgesellschaft*, Nov. 1929, pages 21–28.

There is a general account of the origin and development of the company. The departments of the parent works in Heddernheim are described: the smelting works, the copper works, the brass works and light metal foundry. A list of products manufactured is given. MLM(17)

Rolled Shapes of Aluminum Alloys Now Being Produced. P. M. Heldt. *Automotive Industries*, March 8, 1930, Vol. 62, pages 409–410.

Data on the new blooming and structural rolling mill of the Massena, N. Y. plant of the United States Aluminum Co. are given. GN(17)

A Heat-Treating Job Shop Organized Along Modern Lines. Frank, J. Oliver, Jr. *American Machinist*, Feb. 27, 1930, Vol. 72, pages 375–378.

Describes the heat-treating shops and metallurgical laboratories of the Thurner Heat-Treating Company of Milwaukee. Modern equipment is used throughout. RHP(17)

LABORATORY APPARATUS (21)

A New Type of Laboratory Furnace. *Engineering & Mining Journal*, Feb. 14, 1930, Vol. 129, page 200.

A new type of furnace has been in successful use in the research laboratory of the Carborundum Co., Niagara Falls, N. Y., for several months. Advantages claimed for the furnace are: capacity for producing a temperature of 1500° C. over a short or long firing range; even temperature distribution; cleanliness of operation; compactness; adaptability to transverse and load testing; control of firing atmosphere and quick replacement of heating elements. Details of construction and power curves are shown, also the arrangement permitting variation of power input by changing the top positions on the switchboard. WHB(21)

Laboratory Intense Heat Apparatus. *Brass World*, March 1930, Vol. 26 page 74.

A convenient and complete installation consists of a small tank of dissolved acetylene, a hot-plate, a Bunsen burner, an acetylene-and-air torch with air control, a reducing valve, a 3-way branch valve, and the necessary red gum tubing. The flame is non-oxidizing and non-carbonizing. The Bunsen flame has a temperature of 2800° F. and the needle point flame one of approximately 3300° F. WHB(21)

A New Laboratory Furnace. *Canadian Chemistry & Metallurgy*, March 1930, Vol. 14, page 92.

Babcock & Wilcox Co. is marketing a gas-fired laboratory furnace fitted with an atmospheric burner which requires no auxiliary equipment and can be left to burn unattended with safety. With a gas pressure regulator, a temperature of + or − 10° F. may be maintained for several days. The furnace is brought from room temperature to 2500° F. in 30 minutes, and to 2000° F. in 15 minutes. The maximum temperature is over 2600° F. with illuminating gas under the usual 3″ (water-gage) pressure. A unique baffling arrangement, and a new refractory insulator lining of extremely low heat conductivity are features of the furnace. Natural or manufactured gas may be used. WHB(21)

Book Reviews

The Aluminum Industry. Vol. I. Aluminum and Its Production. 358 pages, 63 figs. **Vol. II. Aluminum Products and Their Fabrication.** 870 pages, 343 figs. By J. D. EDWARDS, F. C. FRARY & ZAY JEFFRIES (Aluminum Company of America). Chemical Engineering Series, McGraw-Hill Book Company, New York, 1st Edition, 1930. Cloth, 6¼ × 9¼ inches. Price, $12.00.

Other authors collaborating are:
E. C. Harder, R. B. Mason, S. K. Colby, R. S. Archer, E. H. Dix, Jr., T. D. Stay, W. Holzhauer, D. B. Hobbs, W. L. Funk, H. E. Bakken, R. L. Templin. F. V. Hartman, W. M. Dunlap, P. V. Faragher, J. D. Porter, E. C. Hartman, J. O. Wesley, G. D. Welty, P. B. Jackson, R. V. Davies, C. F. Nagel, Jr., T. Varney, H. V. Churchill and R. I. Wray.

About 20 years ago the reviewer happened to be in the same squad on a plant inspection trip at an American Electrochemical Society meeting with Dr. Blough, who, with a very few assistants, then constituted the metallurgical staff of the Aluminum Company of America. A third member of the party, who did not know who Dr. Blough was, announced that on his way home he was going to stop as Massena and visit the Aluminum Company's plant, as he wanted to see the reduction pots working. On being asked how he had arranged to be shown that part of the plant, he admitted that he hadn't yet gotten permission. The reviewer then asked Dr. Blough whether such permission could be granted. His reply was, "We don't allow visitors in that part of the Massena plant, but at Shawinigan Falls we have a local regulation allowing priests and nuns, but no others, to go through."

Those were the days when secrecy in electrochemical circles went almost to the extent of armed guards. One Niagara Falls plant hired a furnace operator from its competitor and at the end of his first day on the new job he said to the superintendent, "I can't run the furnace with that ammeter. Your meter shows figures, but I need one like they have in the other plant, that has letters instead of figures. I always ran their furnace with the meter at J."

Conditions have changed since those days. In this book the Aluminum Company sets forth in black and white, facts it has cost the company many millions of dollars to find out, making them available to the public at less than a cent a page.

Although written from the point of view of the Aluminum Company—that of a firm belief in the virtues of aluminum—it is, on the whole, scientifically impartial, as one would expect from men of the standing of the authors. In dealing with resistance to corrosion, for example, the drawbacks are mentioned, though not stressed too strongly. For example, no great stress is laid on the intercrystalline embrittlement of duralumin and no illustrations shown of the way that type of attack progresses, although it is mentioned and the ability of a coating of unalloyed aluminum to resist such attack is emphasized. Since that trouble has been fairly well licked by the coating, the picture given by the book is a pretty accurate one.

So, throughout the book, the effort has been to present facts and present them both accurately and in what the authors believe to be the proper perspective. The company evidently believes that the more widely the true facts as to the properties, the capabilities and the limitations of a given alloy are known, the more uses that alloy will find for which it is fitted and in which it will succeed, and the less the tendency will be for its own salesmen or for prospective users to force it into applications for which it is not so well fitted as is some other material, whether that be another aluminum alloy or some other material.

The value of research in widening markets and the responsibility of the producer of a material to perform that research are well brought out in the quotations below:

"The aluminum industry has had, from the beginning, the benefit of painstaking and increasingly thorough research and technical effort. As each new development in scientific knowledge or equipment has been disclosed, its possible application to the advancement of the knowledge of aluminum has been studied. Not only has this research been directed toward the production of the metal in its various known marketable forms, but large sums of money have been spent to determine how the natural properties of aluminum could be adapted to new commercial uses.

"There is intense competition between practically all materials used commercially. When aluminum replaces copper, steel or wood, it is because its properties and cost present an economic advantage.

"If no new uses for aluminum were developed, and, therefore, no rapid market expansion took place, it would be possible for secondary metal to supply the bulk of the demand, and so materially curtail even the present production of the virgin product.

"The availability of foreign-made ingot in any country is largely a question of supply and demand in other countries. When there is a surplus anywhere, that surplus will seek the most available outlet, and prices will be cut to the bone to keep works operating at full capacity, workmen employed and organization at maximum efficiency . . . . . Thus, there is competition arising between domestic metal and an almost continuous stream of foreign metal which pours into the domestic market. A third form of competition comes through the possible advantages of new and unexploited metals and alloys. Magnesium, for example, ... will find markets in competition with aluminum.

"Regardless of either competition or the natural advantages of aluminum in lightness and durability, the aluminum industry must more and more carry on and extend its pioneering efforts. Many new products and new lines of consumption must be developed before the world will interest itself in the possibilities of replacing its customary raw materials with aluminum. The wooden-chair maker cannot see a future for aluminum chairs. The steel or wooden-door builder rejects the thought that a lighter and stronger door will secure his market. In such cases, the aluminum industry must supply the knowledge and capital for design and production, and create a demand, intelligently directed, for the new products. This is a slow, tedious and expensive process, but with patience and persistence such new uses can and will be developed, and one by one, the industry will pass the milestones on the road to progress."

The first volume deals with the history of the metal, the ores, their purification and their reduction to metal. There is an interesting account of the patent litigation that handicapped the industry in the early days, and the myriads of impractical and impossible purification processes for which patent references are given serve to strengthen our feeling that the patent lawyers' fees and the time spent in prosecuting patents and in resulting litigation represent an enormous economic waste.

The volume gives more information on the electrolytic reduction process and on electrothermal methods of production than has ever been published before.

Much of the data in volume two has been separately published in scientific journals, but is presented in concise form and well indexed. There are some hitherto unpublished data. This volume deals with casting, working, alloying, heat-treatment, properties, design, testing and commercial applications. It contains many equilibrium diagrams and hints on metallographic technique. With all the data it contains, here and there one finds a comment as to lack of needed information on important points. When these gaps are filled and the next revised and enlarged edition is issued, it will have to be published in three volumes. Volume two is a bit heavy as it is, and the reviewer's left hand got reader's cramp from holding it before he had finished it.

The book is complete and authoritative. No one individual and no other group could have done so good a job in discussing the aluminum industry, and few metallurgical industries have as complete information on the fundamental facts as to the metal with which they are concerned and the properties of the alloys they make. Every metallurgical library should include the book.—H. W. GILLETT.

Atlas Metallographicus. Eine Lichtbildsammelung für die technische Metallographie. By H. HANEMANN & A. SCHRADER. Gebrüder Borntraeger, Berlin, 1927. Paper, Portfolio, 8 × 11 inches, Section 1, table 1–8, price 7.50 R. M; Section 2, table 9–16. Price, 6.75 R. M.

In the United States many metallurgists are familiar with Reed's convenient reference book "Microphotographs of Iron and Steel." The "Atlas Metallographicus," which will fulfill the same purpose for Germany will doubtless be one of the standard books in German technical libraries.

The reviewer, in using Reed's book from time to time as a valuable reference, frequently regretted Reed's tendency to present the micrographs in part at low magnification. In the case of the "Atlas Metalligraphicus" the importance of a suitable magnification appears to have been well considered. One of the chief merits of Hanemann and Schrader, in compiling the photographs can be seen in the fact that one and the same structure are shown in various gradually increasing magnifications. It cannot be denied that generally only high magnifications help us to reveal mysteries we encounter quite frequently in our metallographic work.

It is a decided pleasure to look over this work, which has been carried out with the conscientiousness and thoroughness often characteristic of German technical publications. The publisher deserves considerable praise for the excellent reproduction of the photographs.

Judging from the first 2 sections the scope of the material presented will be considerably larger than in Reed's book. The reviewer, therefore, feels the atlas will surpass the goal set, that is to serve the practical metallurgist.

Section 1 contains 8 tables and 64 microphotographs; the first 2 tables are given over to electrolytic iron, the 6 following to structure of forged plain carbon steels. Section 2 contains 8 tables with 57 figures of structures of forged plain steels. A clear description of composition and treatment accompanies each plate.

The metallurgist who already has Reed's book will certainly find much of value in this series. The reviewer eagerly awaits the following sections.—G. NEUENDORFF.

Directory of Trademarks and Trade Names of American Steels —Plain Carbon and Alloy. Report No. 12, Published by the *Iron Age*, New York.

The *Iron Age* has rendered a real service in issuing a directory which tells a good deal that the metallurgically intelligent purchaser wants to know about trade named alloys. For example, Atha 2600 is listed as 22% Ni, 8% Cr, 1.75% Si, 1% Cu; Cocar is 2.15% C, 12% Cr, 0.75% V, 0.75% Co; Midvale ATV3 is 53.5% Fe, 27.5% Ni, 14% Cr, 3.5% W, 1.5% Mn.

The various markings denoting the weight of coating on terne plate are given.

The names are indexed alphabetically, by producers, and by classifications of products.

The directory does not cover tool steels, which have already been listed by the A. S. S. T., nor the trade names referring to cast steel products. It does cover rolled and drawn steels.

It states "Certain producers whose ingot tonnage reaches hundreds of thousands annually are unlisted, simply because their products are made to conform to published specifications, and sold as such." The makers whose names are absent from the list because they have refrained from burdening us with another trade name to remember, and do sell on specification, ought to have their names inscribed on a special roll of honor. It is necessary to have a shorthand term or nickname to use in referring to an alloy of complex constitution, but the multiplication of trade names that refer to the same composition is an irritation.—H. W. G.

Aluminium—Kokillenguss. By H. OBERMÜLLER. V. D. I. Verlag, Berlin, 1929. Paper, 5¾ × 8¼ inches, 84 pages, 40 figs., 16 tables. Price, 4 R. M.

Kokillenguss refers especially to what in this country is known as "permanent mold" and in Europe as "gravity die-cast" foundry practice. The books consists of 85 pages of authoritative and reliable information on this comparatively new process of making high grade aluminum castings.

Due to the fact that such great advances have been made in the past few years in this process, there remained a lack of reliable and definite information on the practice of casting aluminum in metal molds by gravity feed. This condition prevailed in this country more than in Europe where the gravity feed method of casting has advanced ahead of the pressure method. This book should fill this void and should especially appeal to those requiring a thoroughly practical work on this art as it contains many illustrations of typical equipment.

The contents covers all technical and practical phases of this interesting process from a general discussion on the comparative advantages and disadvantages of this method of casting, alloys and their properties with accompanying tables, design and construction of molds, pouring and operating technique, inspection and scrap information, equipment and installation detail and some elements of the economics of the process with a list of parts which are especially adapted to the permanent mold casting practice in aluminum.

It is of special interest to note the similarity of results as reported in this book as compared to those that prevail in this country from the aspect of production figures, cost of molds, scrap figures and other detail.—O. H. Heil.

Bibliography of Aeronautics 1928. National Advisory Committee for Aeronautics. United States Government Printing Office, Washington, D. C., 1930. Cloth, 214 pages. Price, 50 cents.

The Bibliography of Aeronautics for 1928 covers the aeronautical literature published from January 1 to December 31, 1928. Citations of the publications of all nations are included in the languages in which these publications originally appeared. The arrangement is in dictionary form with author and subject entry, and one alphabetical arrangement.—R. R.

Electroplating with Chromium, Copper and Nickel. By Benjamin Freeman & Frederick G. Hoppe. Prentice-Hall, Inc., New York, 1930. Cloth, 6 × 9 inches, 212 pages, 35 figs., 8 plates. Price, $5.00.

Chromium-plating has developed so enormously during recent years that few electroplaters are not called upon to deal with it. This, in itself offers sufficient reason for the publication of a book dealing essentially with chromium-deposition, especially since at the time this book was issued there was no other which adequately treated chromium-plating. The authors are to be commended on realizing, to quote from the preface, "that no book on chromium-plating could be considered complete without a discussion of the closely allied subjects of nickel- and copper-plating," as one or both of these metals are usually applied before the chromium coating. In this respect the book is satisfactory; in others it is disappointing.

The book includes more than its title suggests, as it also has chapters on Electrical and Chemical Fundamentals, Plating-Room Equipment, Polishing and Polishing Compounds, on Cleaning and on the Testing of Deposits. It is very disappointing to find much of this matter treated in a very hurried manner. The theoretical side of electroplating is passed over somewhat sketchily so that, to quote the preface again, "an elementary knowledge of chemistry will, however, be of great help to the reader." This sketchiness is somewhat remedied by the definitions which are frequent enough to form a more or less concise summary of the electrochemical principles involved. The polishing and cleaning of metals and specifications for plating are much better than the first three chapters and give sufficient background for the subsequent chapters on metal deposition.

Of the three metals dealt with, chromium naturally receives most attention. The deposition of copper and nickel should have been treated in more detail. In many instances adequate, scientific explanation worked in with practical fact would have enhanced the value of the chapters. It is unfortunate that in copper deposition sulphuric acid and sodium cyanide and carbonate, and in nickel deposition sodium and magnesium sulphates should have been treated as substances added to the baths as conducting agents when this is not their most important function. Chapter X on chromium-plating is the best in the book and rather emphasizes the shortcomings of the previous two. A noteworthy and valuable inclusion is the section dealing with the importance of correct racking and wiring for successful chromium-plating, the value of the section being enhanced by some twenty clear diagrams. In view of the present knowledge of both practical and theoretical electroplating, the chapters dealing with metal deposition could, with advantage, have been enlarged and amplified, if necessary, at the expense of some of the preceding material which is sufficiently covered in earlier books on electroplating.

The chapter dealing with the testing of deposits and solutions is again marred by a too-brief treatment of the subject matter. The method given for the analysis of a nickel solution for chloride is open to criticism. The chloride is precipitated as silver chloride, by silver nitrate, and after filtering it is recommended that the precipitate be washed "thoroughly with *hydrochloric acid* until the rinsings fail to give a precipitate." Presumably the authors mean washing "thoroughly with *distilled water* until the rinsings fail to give a precipitate with hydrochloric acid." If not, the use of the acid wash should be explained, and also the reagent for testing the rinsings be stated.

The book concludes with some useful appendices and a bibliography. Perhaps the fact that they are fairly recent publications accounts for two important omissions from the latter—the comprehensive bibliography on nickel plating published by the Michigan Engineering Station in November, 1929, and the Bureau of Standards (January 1930) publication on "Throwing Power in Chromium Plating Solutions."

In spite of the shortcomings of the volume, the authors are to be complimented on the readable form of the text. While it will undoubtedly be a useful book to the beginner in electroplating, it will not have the same appeal to either the advanced worker in, or advanced student of, the electrodeposition of metals.—Edward B. Sanigar.

Slaginneslutningar i Järn och Stål. By C. Benedicks & H. Löfquist. A. B. Nordiska Bokhandeln, Stockholm—1929, Paper, 7 × 9½ inches, 338 pages, 139 figs., 1 table. Price, 12 Kr.

It is not at all astonishing that just this book was published in Sweden. The Swedish iron industry, due to its economic position among the iron producing countries of the world, has undoubtedly recognized the main requirements for producing steels of highest quality in advance of the steel industry of other countries. This problem points among others to slag inclusions in steel. Valuable investigations along the line covered by the book have been carried on in recent years in the United States and we, therefore, understand when the authors state in the preface, "It results from the large program of investigation, as projected by the American steel industry, that the slag problem is of greatest importance for the production of high quality steel."

Benedicks' and Löfquist's publication covers the investigations of the Jernkontor, the Swedish Steel Institute. These investigations were made possible by a donation of Robert Hadfield to the Jernkontor in 1926, to carry on this work. The results of their own investigations and those of others all over the world, who have contributed their share to receive a better insight in this predominant problem of metallurgy, are considered in the 7 chapters of the book.

After an outline of the scope of the book, equilibrium diagrams and origin of slags are described in Chapter 2. Microscopic and macroscopic tests to determine qualitative as well as quantitative amounts of slag inclusions follow. Chapters 4 and 5 will be of greatest interest to the practical steelmaker. Chapter 4 deals with size and distribution of slag inclusions in metals and Chapter 5 with the influence of slag particles on the physical properties of the product. In the last 2 short chapters the slag contents of different processed steels are considered and the possibilities of reducing the slag contents in steel are discussed. The 18-page bibliography has subject and author indexes and a table, covering the properties of the most important slag components.

There is no doubt as to the authors hope, as expressed in the preface, that the pains taken in summarizing the present known facts on slags will be of value to the metallurgist as well as the consumer will be fulfilled. The reviewer has been informed by one of the authors (Mr. Löfquist) that a translation into English is being arranged.—G. Neuendorff.

Reviews of Manufacturers' Literature

In this department we shall list each month a selection of the catalogs, books, treatises and other printed matter issued by manufacturers which, in our judgment should be of interest to the readers of Metals & Alloys. *Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter for consideration by the editor of this department are invited to do so, and it is suggested that* Metals & Alloys *be placed on the regular mailing list so that advance copies of any material of interest to the metallurgical field may automatically come to this department*—Editor.

After 50 Years Ajax Still Shows the Way.—Anniversary booklet giving a brief historical sketch of the development of the Ajax Metal Company and the Ajax Electric Furnaces, Ajax Metal Company, Philadelphia, Pa. *By the same Company* Catalog 22 covering the Ajax-Wyatt Electric Furnaces profusely illustrated with installation as well as descriptive photographs.

Checking Pyrometers and Thermocouples.—Direct mail piece on the Treasure Chest—a potentiometer for checking pyrometers. Thwing Instrument Company, 3339 Lancaster Ave., Philadelphia, Pa.

Engine Indicator Valve.—Bulletin 1266. Leaflet illustrates and describes briefly the Maihak Indicator Valve. Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

Metered Combustion Control.—Leaflet entitled "Load Distribution is Flexible" illustrates the flexible regulation of the L & N combustion control. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

Measuring Tools.—400-page catalog gives information on the products of the Goodell-Pratt Co. Complete Catalog No. 16. Goodell-Pratt Co., Greenfield, Mass.

Use of Nickel in Non-Ferrous Castings.—Booklet reviews the uses of nickel in brasses and bronzes, its effects on their properties. White metals, nickel silvers, light aluminum alloys, Monel metal and other copper alloys, electrolytic nickel. 16 pages. International Nickel Co., 67 Wall St., New York, N. Y.

Special Steels and Alloys.—General Catalog of Acieries D'Imphy gives information on the various products of the company. Tables in the appendix give heat treatment, uses, methods of working, and physical properties of many of the materials. This 60-page booklet is printed in French. R. Y. Ferner Co., Investment Bldg., Washington, D. C.

Metal Finishing.—Bulletin 10 discusses the important factors in the preparation of metal surfaces for finishing and Bulletin 12 the priming of metal surfaces. These bulletins are the first of a series on lacquers and lacquer finishing using pyroxylin products. Pyroxylin Products, Inc., 4851 S. St. Louis Ave., Chicago, Ill.

Accessories for Spectrometers and Spectrographs.—44-page bulletin contains information on various accessories: condensers, absorption tubes, slits, micrometer eyepieces, vacuum pumps, rare gases, rare metals, thermopiles, photo-electric cells, etc. Adam Hilger, Ltd., 24 Rochester Place, Camden Road, London, N.W.1, England.

Analytical Precision for the Research Laboratory.—This is the title of a 104-page booklet which contains information on the following instruments: Colorimeters, Nephelometers, Hemoglobinometers, Scopometers, Refractometers, Spectroscopes, Polariscopes. Bausch & Lomb Optical Company, Rochester, N. Y.

Automatic Temperature Controllers. Booklet, 12 pages contains illustrations of automatic controller installations. Wilson-Maeulen Co., 387 Concord Ave., New York, N. Y.

Apparatus for the Preparation and Examination of Mineral Specimens.—Five multigraphed bulletins describing the cutting, grinding and polishing machines for mineralogical sections. E. Leitz, Inc., 60 East 10th Street, New York, N. Y.

Bridge-Meg. Circular 515 describes device for making electrical resistance measurements up to 100 megohms. James G. Biddle, 1211 Arch Street, Philadelphia, Pa.

Lathes.—Bulletin No. 9 describes new model 9-inch lathe; Bulletin 15 new model 15-inch lathe; General Catalog No. 91-A is a 108-page book giving descriptions and illustrations of 96 sizes and types of precision lathes. South Bend Lathe Works, South Bend, Indiana.

Photoelectric Spectrophotometer. Bulletin 101 describes and illustrates the instrument. American Photoelectric Corp., 149 Broadway, New York, N. Y.

Hennig Purifier and Desulphurizer.—Reprint of an article from *The Foundry* entitled "Use Sodium Flux for Iron." Columbia Products Co., Barberton, Ohio. Other literature published by the same company: Purifying Steel with Sodium Compounds.

Pulverizing Mills.—Four-page leaflet gives economic and mechanical advantages of Fuller Lehigh Mills, both of the air and of the screen separation type. Circular 902. Fuller Lehigh Co., Fullerton, Pa.

Gas-Fired Furnaces.—Direct mail piece gives brief information of installation of three S-C furnaces at Whitney Metal Tool Co., Rockford, Ill. Surface Combustion Co., 2375 Dorr St., Toledo, Ohio.

Mercoids.—The April 1930 issue of this house organ is dedicated to the new plant of the Mercoid Corporation. An article on Economics of Automatic Control of Unit Heaters is included. The Mercoid Corp., 4201 Belmont Ave., Chicago, Ill.

Tycos Rochester.—The April issue of Tycos-Rochester contains the following articles: Uncle Sam Attempting to Solve Ancient Problem; Science Seeks to Hatch Artificial Weather; Nothing in the World Colder Than This Place; Fathoming Neptune's Secret; Power from Ocean Temperature; Actual and Normal Weather Conditions; Navy Aerologists Studying Weather Puzzles. Taylor Instruments Companies, Rochester, N. Y.

Technical Measuring Instruments.—Bulletin gives information on the complete line of instruments manufactured by Lehmann & Michels: instruments for indicating power; Shaft Horse Power; Vibration Study; Material Testing; Special Testing. This is printed in English. Lehmann & Michels, Hamburg-Altona, Abt. I, Germany.

The Laboratory.—Volume Three, Number Two of *The Laboratory* contains the following: Lavoisier, Founder of Modern Chemistry; Carbon Determination in High Sulphur Steels; and several instrument descriptions. Fisher Scientific Company, 711 Forbes St., Pittsburgh, Pa.

Mikrotast Indicators.—Leaflet covers Krupp Mikrotast Indicators. Coats Machine Tool Co., Inc., New York, N. Y.

Arc Welding.—In arc welding Bulletin 12, G. D. Fish gives methods of estimating the cost of arc welding steel structures. Several illustrations are included, and the actual figures given are those used in the construction of the 17 shop and office buildings and the three bridges erected on the properties of the Westinghouse Co. by arc welding. Bulletin 13 gives a discussion of arc welded jugs and fixtures. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Steel Castings.—Folder entitled "Tons of Material Swing High and Safe on Lebanon Steel Castings" illustrates various castings used in the Shepard Hoists. Lebanon Steel Foundry, Lebanon, Pa.

Patent Department

Through an arrangement with Mr. W. M. Corse, Metallurgical Engineer, Washington, D. C., who operates a well-known Patent Information Service, we are able to publish every month a list of important patents in the metallurgical field from the United States, Canada and Europe. The following countries will be included in the European listing: England, Germany, France, Switzerland, Denmark, Norway, Sweden and Italy.

If our readers wish more information about any of the patents listed below they can get it by writing to our Patent Department, and mentioning the fact that they have the reference in METALS & ALLOYS. *We will be prepared to mail copies of United States Patents to clients within twenty-four hours of date of issue by special arrangement. Photostatic copies, translations of claims and of full text of foreign patents will be supplied if desired.*

This service is furnished under special arrangement with Mr. Corse's organization at most reasonable rates. Full information can be secured by writing to Patent Department, METALS & ALLOYS, *419 Fourth Avenue, New York.*

United States Patents

Subject of Invention, Patentee, Patent No. and Filing Date

Metallurgy of metals. H. H. Alexander, Westfield, N. J. No. 1,756,967. July 21, 1926.

Hot-metal Car. C. P. Astrom, East Orange, N. J., assignor to M. H. Treadwell Co., Inc., New York, N. Y. No. 1,757,000. Jan. 25, 1929. Original filing date, Mar. 8, 1928.

Process of electrolytically refining copper or copper alloys. M. Hosenfeld and G. Hänsel, Berlin, Germany, assignors to Siemens & Halske A.-G. Berlin-Charlottenburg, Germany. No. 1,757,047. July 24, 1926; in Germany Jan. 6, 1926.

Soldering flux. F. E. Harris, Bellingham, Wash. No. 1,757,118. Mar. 2, 1929.

Magnetic Material. G. W. Elmen, Leonia, N. J., assignor to the Bell Telephone Laboratories Inc., New York, N. Y. No. 1,757,178. Apr. 2, 1929.

Foundry molding box. A. B. Smith and C. R. Smith, Wolverhampton, England. No. 1,757,226. Apr. 6, 1929; in Great Britain Apr. 16, 1928.

Process of producing low carbon alloys. F. A. Fahrenwald, Chicago Heights, Ill. No. 1,757,298. May 29, 1926.

Alloy (Ni-Cu-Ag). M. E. Barker, U. S. Army, Cambridge, Mass., assignor of one-fifth to H. H. Semmes, Washington, D. C. No. 1,757,507. Sept. 5, 1928.

Alloy (Ni-Fe-Ag). M. E. Barker, U. S. Army, Cambridge, Mass., assignor of one-fifth to H. H. Semmes, Washington, D. C. No. 1,757,508. April 30, 1928.

Furnace for treating zinc ores and other zinciferous material. A. Roitzheim and W. Remy, Berlin-Oberschoneweide, Germany. No. 1,755,076. Apr. 23, 1926, in Germany Nov. 13, 1925.

Hanger for articles to be plated. L. Lichtman, assignor to Chromeplate Co., both of New York, N. Y. No. 1,755,122-3. Nov. 27, 1928.

Process for deoxidizing copper. C. S. Smith, Cambridge, Mass., assignor of one-half to C. R. Hayward, Quincy, Mass. No. 1,755,309. July 8, 1926.

Open-die-heading machine. C. T. Brennan, Waterbury, Conn. No. 1,755,312. June 29, 1928.

Welding hydraulic apparatus. J. B. Hendrickson, Philadelphia, Pa., assignor to Welding Engineers, Inc. No. 1,755,321. Apr. 2, 1926.

Machine for forming hot metal. A. O. Herron, Waterbury, Conn. No. 1,755,323. Sept. 14, 1928.

Nut-forging machine. J. A. Kinney, Lebanon, Pa., assignor to Bethlehem Steel Co. No. 1,755,325. Mar. 31, 1926.

Electric-furnace resistor. F. A. Fahrenwald, Cleveland Heights, Ohio. No. 1,755,350. May 19, 1924.

Method and means for electrolytic production of light metals. E. O. Barstow, assignor to The Dow Chemical Co., both of Midland, Mich. No. 1,755,380. Nov. 9, 1925.

Process of producing a phosphate coating on metal. M. Green and V. M. Darsey, assignors to Parker Rust-Proof Co., all of Detroit, Mich. No. 1,755,391. Apr. 29, 1929.

Ladle. W. H. Peirce, Baltimore, Md., assignor to American Smelting & Refining Co., New York, N. Y. No. 1,755,411. May 10, 1928.

Method of welding materials of dissimilar thermal characteristics. W. M. Chace, Detroit, Mich., A. H. Lindley, A. Cooper and H. B. Chace, executors of said W. M. Chace, deceased, assignors to W. M. Chace Valve Co., Detroit, Mich. No. 1,755,425. Sept. 14, 1927.

Heat-treated nickel-copper-aluminum alloy and method of heat treating the same. W. A. Mudge, Huntington, W. Va., assignor, by mesne assignment to the International Nickel Co., Inc., New York, N. Y. No. 1,755,554. June 10, 1924.

Manufacture of alloys of copper, nickel and aluminum. W. A. Mudge, Huntington, W. Va., assignor, by mesne assignments to The International Nickel Co., Inc., New York, N. Y. No. 1,755,555. Mar. 31, 1925.

Heat-treated copper-nickel-aluminum alloy. W. A. Mudge, Huntington, W. Va., assignor by mesne assignments, to The International Nickel Co., Inc., New York, N. Y. No. 1,755,556. July 13, 1925.

Copper-nickel-aluminum alloy and method of heat treating the same. W. A. Mudge, Huntington, W. Va., assignor by mesne assignments, to The International Nickel Co., Inc. New York, N. Y. No. 1,755,557. July 13, 1925.

Galvanizing. C. Pletsch, Bad-Nauheim, Germany. No. 1,755,559. May 15, 1924.

Ingot-feeder clamp and shoulder support. A. L. Schwab, New Philadelphia, Ohio. No. 1,755,669. Apr. 13, 1929.

Molding machine. F. R. Wallace, Philadelphia, Pa., assignor to The Tabor Manufacturing Co., Philadelphia, Pa. No. 1,755,679. Jan. 17, 1928.

Coated metal and process of making the same. F. W. de Jahn and J. G. Dely, New York, N. Y., assignors to Chemical Research & Designing Corp., New York, N. Y. No. 1,755,686. Oct. 10, 1929.

Molding machine. J. T. Ramsden, assignor to The Tabor Manufacturing Co., both of Philadelphia, Pa. No. 1,755,704. Nov. 5, 1927.

Process of recovering volatilizable metals from ores or the like. H. Stephani, Magdeburg, Germany, assignor to the Firm Fried. Krupp Grusonwerk Akt.-Ges.,-Magdeburg-Buckau, Germany. No. 1,755,712. Apr. 11, 1927; in Germany Apr. 12, 1926.

Pickling apparatus. S. L. Williams, Bridgeport, O., assignor to Extruded Metal Products Co., Bridgeport, Ohio. No. 1,755,719. June 19, 1929.

Apparatus for normalizing and pickling metals. F. J. Winder, Brackenridge, Pa., assignor to Allegheny Steel Co. No. 1,755,755. Mar. 16, 1928.

Welding machine. M. H. Sussman, Kew Gardens, N. Y. No. 1,755,799. June 29, 1929.

Inhibitor material. L. J, Christmann, Jersey City, N. J., assignor to American Cyanamid Co., New York, N. Y. No. 1,755,812. Sept. 18, 1929.

Process of and apparatus for smelting ores and recovering by-products therefrom. F. T. Snyder, New Canaan, Conn. No. 1,755,845. June 8 1925.

Heating furnace. H. Holiday, W. McKnight and J. G. Christfield, Butler, Pa., assignors to The American Rolling Mill Co., Middletown, Ohio, by mesne assignments. No. 1,755,875. Feb. 2, 1928.

Welding torch. A Krebs, Jamaica Plain, Mass. No. 1,755,882. Dec. 6, 1926.

Process for producing composite metals. H. L. Coles, assignor to Guardian Metals Co., both of Hamilton, O. No. 1,755,913. Nov. 9, 1928.

Granulated product and process for making same. (*Dust from reduction of arsenical ores.*) H. C. Gardiner, Anaconda, Mont. No. 1,755,985. Aug. 22, 1927.

Hot punching and shearing machine. J. Kurkowski, Carrick, Pa., assignor to Jones & Laughlin Steel Corporation, Pittsburgh, Pa. No. 1,755,994. Feb. 11, 1927.

Process for treating mixtures of oxy salts of arsenic, antimony and tin. M. F. Perkins, Tacoma, Wash., and C. W. Hanson, Perth Amboy and B. M. O'Hara, Westfield, N. J., assignors to American Smelting and Refining Co., New York, N. Y. No. 1,756,007. Jan. 20, 1927.

Plate catcher. F. R. Krause and R. C. Stiefel, Ellwood City, Pa. No. 1,755, 356. Feb. 26, 1929.

Method of utilizing bundled scrap metal. F. Wüst, Düsseldorf, Germany, assignor to the Firm Th. Goldschmidt A.-G., Essen, Germany. No 1,756,049. Aug. 19, 1926; in Germany Sept. 2, 1925.

Process of welding. A. G. Crum, Pittsburgh, Pa., assignor to Metal & Thermit Corporation, Carteret, N. J. No. 1,756,054. Feb. 12, 1927.

Method of refining nickel-copper matte. F. E. Lathe, Ottawa, Ontario, Canada. No. 1,756,092. Dec. 13, 1928.

Apparatus for molding plugs and the like. C. M. Hart, Waycross, Ga. No. 1,756,193. Oct. 15, 1927.

Method of making metal sheets. B. F. Hopkins and J. V. O. Palm, Cleveland Heights, O., assignors to The Cleveland Graphite Bronze Co., Cleveland, Ohio. No. 1,756,196. Feb. 23, 1928.

Rod or wire drawing block. F. H. Nullmeyer, Sturthers, O. No. 1,756,206. Oct. 21, 1924.

High-speed tool-steel alloy. G. R. Couls, Detroit, Mich. No. 1,756,282. Sept. 1, 1927.

Method of cleaning metals. W. L. Semon, Cuyahoga Falls, O., assignor to The B. F. Goodrich Co., New York, N. Y. No. 1,756,311. Feb. 20, 1929.

Metal pickling. J. C. Vignos, Nitro, W. Va., assignor to The Rubber Service Laboratories Co., Akron, O. No. 1,756,317. Apr. 18, 1928.

Iron smelting. R. Franchot, Washington, D. C., assignor to Ferro Chemicals. Inc., Washington, D. C. No. 1,756,349. Mar. 15, 1928.

Method of electrically welding pipes. C. M. Thomson, Westmount, Quebec. No. 1,756,403. Jan. 18, 1929.

Manufacture of objects consisting of refractory, insulating, abrasive or like substances. M. Fourment, Paris, France. No. 1,756,457. Dec. 13, 1927.

Open-hearth furnace. W. Gast, Philadelphia, Pa. No. 1,756,484. June 23, 1921.

Electrode holder. (*For welding electrodes*). C. H. Hollup, Chicago, Ill. assignor to Hollup Corp. No. 1,756,556. July 18, 1928.

Metallic welding rod. H. R. Pennington, Chicago, Ill., assignor to Hollup Corp. No. 1,756,568. Aug. 4, 1927.

Attachment for casting machines. A. W. Morris, Drexel Hill and S. P. Wetherill, Jr., Haverford, Pa., assignors to Wetherill-Morris Engineering Co., Philadelphia, Pa. No. 1,756,602. May 22, 1929.

Multiple casting machine. H. A. W. Wood, New York, N. Y., assignor to Wood Newspaper Machinery Corp., New York. No. 1,756,617. Aug. 19, 1926.

Funace-charging conveyer. A. R. McArthur, Gary, Ind., assignor to American Sheet and Tin Plate Co. No. 1,756,653. Oct. 19, 1928.

Casting machine. H. C. Merrill, assignor to The Eagle-Picher Lead Co., both of Cincinnati, O. No. 1,756,654. Apr. 8, 1927.

Apparatus for applying a soft-metal surfacing to hard-metal plates. A. Gunthard, Arcola, N. J., assignor to The Chemical Equipment Manufacturing Co., Paterson, N. J. No. 1,756,739. Sept. 7, 1928.

Molding machines. J. R. Wood, Hatboro, Pa., assignor to New Process Multi-Castings Co. No. 1,756,776. June 2, 1926.

Method and apparatus for extracting castings from molds. L. A. Camerota, Burlington, N. J., assignor to W. Wood, Philadelphia, Pa., No. 1,756, 812. June 5, 1928.

Hard-metal composition and method of making the same. E. G. Gilson, Colonie, N. Y., assignor to General Electric Co. No. 1,756,857. April 28, 1927.

Manufacture of hollow metal rods, bars and the like. R. A. Hadfield, Westminster, England. No. 1,757,524. Jan. 24, 1929; in Great Britain, July 7, 1927.

Apparatus for welding. J. A. Muir, Detroit, Mich. No. 1,757,540. May 11, 1927.

Ingot mold and ingot. E. Gathmann, Baltimore, Md. No. 1,757,663. May 23, 1929.

Electrode. J. Westly, Kristiansand, Norway, assignor to Det Norske, A/S for Elektrokemisk Industri of Norway, Oslo, Norway. No. 1,757,695. Sept. 23, 1926; in Norway, Sept. 30, 1925.

Nickel Anode. G. B. Hogaboom, Matawan, N. J., assignor to Hanson-Van Winkle-Munning Co., Matawan, N. J. No. 1,757,714. Feb. 28, 1929.

Apparatus for treating material. K. T. Potthoff, Brooklyn, N. Y., assignor to U. S. Galvanizing & Plating Equipment Corp. No. 1,757,735. June 8, 1927.

Cushion for sheet metal presses. F. J. Rode, Chicago, Ill., assignor to Marquette Tool & Mfg. Co., Chicago, Ill. Nos. 1,757,737 and 1,757,738. Feb. 9, 1929.

Furnace for treating sheet metal or the like. F. Wille, Chicago, Ill. No. 1,757,789. May 4, 1927.

Process for making reinforced non-corrosive steel. P. A. E. Armstrong, Loudonville, N. Y., assignor to Ludlum Steel Company, Watervliet, N. Y. No. 1,757,790. Jan. 5, 1922.

Metal-spinning machine. J. L. Adams, Jr., East Chicago, Ind., assignor of nine-tenths to Graver Corp., East Chicago, Ind. No. 1,757,824. Feb. 28, 1928.

Pickling of metals. V. Bertleff, Zilina, Czechoslovakia. No. 1,757,829. June 27, 1928; in Austria July 9, 1927.

Manufacture of bodies for tools and the like from materials such as carbides the alloys thereof and the like. K. Schröter, Berlin-Lichtenberg and H. Wolff, Berlin, Germany, assignors to Fried. Krupp, Akt.-Ges., Essen/Ruhr, Germany. No. 1,757,846. June 10, 1929; in Germany June 15, 1928.

Sintering apparatus. A. Holmberg, Stockholm, Sweden. No. 1,757,863. Jan. 28, 1928.

Electric Furnace. A. J. Asch, New York, N. Y. No. 1,757,895. Jan. 5, 1928.

Foam-producing process and material for acid metal-cleaning baths. J. H. Gravell, Elkins Park, Pa., assignor to American Chemical Paint Company, Ambler, Pa. 1,757,959. Mar. 29, 1927. Renewed Mar. 20 1930.

Dental casting machine. L. C. Burgard, Louisville, Ky. No. 1,757,991. June 16, 1927, Renewed Sept. 20, 1929.

Method of heat treating electrical devices. H. D. Madden, Montclair, N. J., Assignor to Westinghouse Lamp Co. 1,758,004. Oct. 27, 1926.

Welding torch. J. Nagy, Long Island City, N. Y. No. 1,758,054. May 16, 1928.

Parting-facing product for casting metals. B. F. Wallace, Brooklyn, N. Y. No. 1,758,095. Jan. 8, 1926.

Forming metal castings. A. Kadow, Toledo, Ohio, assignor of one-half to W. Owen and C. W. Owen, Toledo, Ohio. No. 1,758,113. Mar. 15, 1926.

Means and method for filling molds with molten metal. A. Kadow, Toledo, Ohio, assignor, by direct and mesne assignments, to the Vacuum Casting Co., Toledo, Ohio. No. 1,758,114. Mar. 15, 1926.

Mechanical ore roasting furnace. J. Harris, Sheffield, England. No. 1,758,154. May 21, 1928; in Great Britain June 2, 1927.

Method of roasting fines. H. J. Cordy and W. J. Burgoyne, Sulphide Ont., assignors to General Chemical Co., New York, N. Y. No. 1,758,188. Jan. 30, 1928.

Tarnish resisting silver and silver plate and process for producing the same. W. S. Murray, Utica, N. Y., assignor to Oneida Community Limited, Oneida, N. Y. No. 1,758,293. Sept. 19, 1924; renewed Oct. 3, 1929.

Casting machine. H. Spiro, Chicago, Ill. No. 1,758,380. Nov. 2, 1927.

Method of producing a coating stable toward acids and alkalis on metallic articles. F. Ahrens, Bockenem-on-Harz, Germany, assignor of one-half to Harzer Achsenwerke G. m. b. H., Bornum on-the-Harz, Germany. No. 1,758,420. July 7, 1927; in Germany May 18, 1925.

Silico-thermic Metallurgy. W. C. Read, Scarsdale, N. Y., assignor to Electro Metallurgical Company. No. 1,758,465. Nov. 21, 1928.

Coating articles, particularly with metals. M. U. Schoop, Hoengg, Switzerland. No. 1,758,473. June 26, 1925; in Switzerland, June 30, 1924.

Method for casting pipes. J. H. Uhrig, Beverley, N. J., assignor to United States Cast Iron Pipe and Foundry Co., Burlington, N. J. No. 1,758,483. May 18, 1928.

Mold. W. M. Weil, Cleveland, Ohio, assignor to the National Smelting Co., Cleveland, Ohio. No. 1,758,488. Feb. 11, 1929.

Soldering tweezers. J. Aderer, New York, N. Y. No. 1,758,490. Jan. 4, 1929.

Vacuum dispersion coating process. W. A. F. Pfanhauser, Leipzig, Germany, assignor to Gesellschaft für Elektrodenzerstaubung G.m.b.H., Bohlitz-Ehrenberg, Leipzig, Germany. No. 1,758,531. Oct. 10, 1927; in Germany Oct. 22, 1926.

Die-rolling process and apparatus. W. H. Donner, Buffalo, N. Y. No. 1,758,563. Apr. 30, 1926.

Pad for electroplating devices. P. J. F. Batenburg, Racine and C. J. Atkinson, Milwaukee, Wis.; said Atkinson assignor to said Batenburg. No. 1,758,682. July 13, 1925.

Straightening machine. B. P. Hazeltine, Baltimore, Md. No. 1,758,699. Dec. 8, 1928.

Apparatus for subjecting a mass of powdered or granular material to the action of gases, particularly applicable to the calcining and roasting of ores and similar materials. H. M. Ridge, London, England. No. 1,758,805. May 9, 1928.

Method of and an apparatus for treating the tubes of surface condensers and the like to prevent corrosive action. J. Austin and H. Smith, Liverpool, England. No. 1,758,810. Dec. 16, 1925; in Great Britain Dec. 30, 1924.

Apparatus for making cores. G. W. Gilderman, Mishawaka, Ind., assignor to Dodge Mfg. Corp., Mishawaka, Ind. No. 1,758,888. June 4, 1927.

Core. G. W. Gilderman, Mishawaka, Ind., assignor to Dodge Mfg. Corp., Mishawaka, Ind. No. 1,758,889. Apr. 26, 1928; original application filed June 4, 1927.

Process for making cores. G. W. Gilderman, Mishawaka, Ind., assignor to Dodge Mfg. Corp., Mishawaka, Ind. No. 1,758,890. Apr. 26, 1928. Original application filed June 4, 1927.

Welding fixture. A. Brantingham, Rockford, Ill., assignor to Emerson-Brantingham Corp., Rockford, Ill. No. 1,759,036. Oct. 31, 1927.

Bending Machine. W. C. Irvin, Oakland, Calif., assignor to Yager Sheet Metal Co., Oakland, Calif. No. 1,759,053. Nov. 18, 1927.

Method of smelting copper. A. D. Wilkinson, Cananea, Mexico, assignor to the Cananea Consolidated Copper Co., S. A., Sonora, Mexico. No. 1,759,078. Mar. 26, 1926.

Process of manufacturing reflectors. C. W. Dake, Chicago, Ill., assignor to the Pyle-National Co., Chicago, Ill. No. 1,759,099. Mar. 19, 1926.

Tuyère for blast furnaces. E. H. Holzworth, Buffalo, N. Y. No. 1,759,114. May 17, 1927.

Means for electroplating tubes internally and externally. V. L. Soderberg, Detroit, Mich., and C. R. Gleason, Chicago, Ill. No. 1,759,171. May 12, 1927.

Method of and apparatus for reducing metallic oxides without melting. W. H. Smith, Detroit, Mich. No. 1,759,173. May 10, 1928.

Molding Machine. E. O. Beardsley and W. F. Piper, Chicago, Ill., assignors to the Beardsley & Piper Co., Chicago, Ill. No. 1,759,217. Feb. 17, 1926.

Rolling Mill. J. Kennedy, Pittsburgh, Pa. No. 1,759, 262. June 23, 1926.

Manufacture of iron carbonyl. A. Mittasch, Ludwigshafen a.Rh., and C. Müller, Mannheim, Germany, assignors to I. G. Farbindustrie Akt.-Ges Frankfurt a.M., Germany. No. 1,759,268. Jan. 29, 1925; in Germany Feb. 1, 1924.

Apparatus for casting molten metal or other fluent or semifluent material. F. C. Morrison, Syracuse, N. Y. No. 1,759,269. Feb. 6, 1928.

Material for the low temperature soldering of metals. J. A. Rognon, Levallois Perret, France. No. 1,759,279. July 20, 1929; in France July 24, 1928.

Cutting-torch holder. J. Temple, Portland, Ore. No. 1,759,288. June 14, 1926.

Iron refining. G. S. Evans, Bronxville, N. Y., assignor to the Mathieson Alkali Works, New York, N. Y. No. 1,759,347. Feb. 28, 1928.

Method and apparatus for treating hot galvanized articles. C. A. Giblin, Westfield, N. J., assignor to H. B. Newhall Corp., Garwood, N. J. No. 1,759,450. Sept. 15, 1928.

Uranium metal and product and process of making the same (Mo-U). J. A Henry, New Haven, Conn., assignor by mesne assignments to Arcturus Radio Tube Company, Newark, N. J. No. 1,759,454. Oct. 22, 1925.

Process of extracting useful elements from their ores by the aid of gases. B. Hofseth, Leirbotn, Norway. No. 1,759,456. Aug. 25, 1927; in Norway Sept. 10, 1926.

Alloy of high surface stability comprising nickel and silicon. P. A. E. Armstrong, Loudenville, and R. P. De Vries, Newtonville, N. Y., assignors, by direct and mesne assignments to Ludlum Steel Company, Watervliet, N. Y. No. 1,759,477. Jan. 7, 1921.

Metal Rolling. R. S. A. Dougherty and N. Greenwell, Bethlehem, Pa. No. 1,759,481. May 7, 1927.

Method of electrolysis. U. C. Tainton, East St. Louis, Ill. No. 1,759,493. Apr. 1, 1926; renewed May 13, 1929.

Method for the recovery of lead and other metals from ores or other lead-bearing materials. U. C. Tainton, Johannesburg, South Africa. No. 1,759,494. Sept. 19, 1927.

Blast furnace for reduction and recovery of volatilizable metals as oxides and method of operating the same. W. Job, Berlin-Dahlem, Germany, assignor to American Lurgi Corp., New York, N. Y. No. 1,759,559. June 29, 1926; in Germany July 2, 1925.

Stable-surface alloy steel. Ralph P. DeVries, Newtonville, N. Y., assignor to Ludlum Steel Co., Watervliet, N. Y. No. 1,759,605. Jan. 20, 1926; No. 1,759,606. Jan. 22, 1926.

Method of producing magnetic bodies. F. J. Given, East Orange; R. M. C. Greenidge, Orange; and J. R. Weeks, Jr., East Orange, N. J., assignors to Bell Telephone Laboratories, Inc., New York, N. Y. No. 1,759,612. June 6, 1929.

Apparatus for handling sand in foundries. W. E. Naylor, Chicago, Ill., assignor to The Beardsley & Piper Co., Chicago, Ill. No. 1,759,625. Feb. 7, 1927.

Treatment of iron or steel. K. B. Thews, Drexel Hill, and J. S. Carlitz, Philadelphia, Pa. said Carlitz assignor to said Thews. Nos. 1,759,634 and 1,759,635. Dec. 7, 1929.

Manufacture of pure iron. A. Mittasch, and E. Linckh, Ludwigshafen a. Rh. and C. Müller, Mannheim, Germany, assignors to I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 1,759,658. Dec. 21, 1925; in Germany Dec. 15, 1924. No. 1,759,660. July 2, 1927; in Germany July 5, 1926.

Manufacture of pure iron. A. Mittasch, and W. Schubardt, Ludwigshafen a.Rh.; and C. Müller, Mannheim, Germany, assignors to I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 1,759,659. Mar. 4, 1926; in Germany May 23, 1925.

Finely divided metals from metallic carbonyls. C. Müller, Mannheim; and W. Schubardt, Ludwigshafen a.Rh., Germany, assignors to I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 1,759,661. July 2, 1927; in Germany July 6, 1926.

Weld rod for electric arc welding. A. W. Carlson, Milwaukee, Wis., assignor to A. O. Smith Corp., Milwaukee, Wis. No. 1,759,686. May 23, 1929.

Method for working up iron ores in a direct way. P. H. Ledeoer, Paris, France, assignor to Staalsyndicat Dr. Ledeboer II, The Hague, Netherlands. No. 1,759,753. Mar. 17, 1928; in the Netherlands Mar. 30, 1927.

Removing incrustation formed on metallic surfaces. R. Seligman, London, England. No. 1,759,762. Aug. 1, 1927; in Great Britain Nov. 4, 1926.

Process of treating ferrous metal articles. M. C. Baker and W. A. Dingman, Detroit, Mich., assignors to Parker Rust Proof Co., Detroit, Mich. No. 1,761,186. June 30, 1928.

Resistance welding apparatus. D. F. Pancoast, Cleveland, Ohio. No. 1,761,276. Jan. 19, 1928.

Apparatus for collecting suspended dust. H. Waring, Lancashire, Eng., assignor to Associated Lead Manufacturers Limited, London, Eng. No. 1,761,377. Mar. 9, 1927; in Great Britain, Aug. 28, 1926.

Apparatus for welding with high frequency currents. E. J. von Henke, Chicago, Illinois, assignor to American Electric Fusion Corp., Chicago, Ill. No. 1,761,420. Apr. 16, 1926.

Electrical welding Apparatus. E. J. von Henke, Chicago, Ill., assignor to American Electric Fusion Corp., Chicago, Ill. No. 1,761,421. June 12, 1923; Dec. 5, 1922.

Furnace for the production of aluminum. P. E. Frøland, Hoyanger, Norway, No. 1,761,442. Mar. 1, 1928; in Norway Mar. 12, 1927.

Method of making articles of lead-copper and analogous alloys. H. M. Williams, Dayton, Ohio, assignor to General Motors Research Corporation. No. 1,761,506. July 22, 1925.

Metallurgical process. (For treating sulphide ores.) R. D. Pike, Piedmont, Calif. No. 1,761,641. Feb. 11, 1926.

Manufacture of rails and tie plates. J. D. Jones, Sault Ste. Marie, Ont., assignor to E. Gathmann, Baltimore, Md. No. 1,761,672. Dec. 7, 1926.

Metallic electrode holder. (For welding.) H. H. Heckman, Detroit, Mich., No. 1,761,728. Nov. 19, 1926.

Molding machine. T. E. McFall, Sparta, Mich., assignor to Sparta Foundry Co., Sparta, Mich. No. 1,761,736. Apr. 23, 1928.

Process of making metal-working tools. E. F. Smith, Chicago, Ill., assignor to Haynes Stellite Co., Kokomo, Ind. No. 1,761,755. Aug. 14, 1926.

Process for coating, impregnating or alloying metals and other materials with aluminum and aluminum alloys. W. Smith, West Hartlepool, England, assignor to The Expanded Metal Company, Ltd., London, England. No. 1,761,850. Mar. 2, 1927; in Great Britain Mar. 17, 1926

Alloy steel and method of making the same (Austenitic-Co-Ni-Si steel). R. E. Bissell, Cleveland Heights, Ohio, assignor to Thompson Products Co. No. 1,761,866. Feb. 8, 1928.

Method and means for upsetting sheet metal. H. Junkers, Dessau, Germany. Nos. 1,761,887. Aug. 3, 1925; 1,761,888. Nov. 27, 1926. (Original application filed Aug. 3, 1925); in Germany Aug. 15, 1924.

Method of rustproofing iron or steel. A. W. Schluchter, Dearborn, Mich., Assignor to General Motors Research Corp., Detroit, Mich. No. 1,761,936. Dec. 24, 1928.

Electroplating process. R. J. Wirshing and H. R. Faas, Detroit, Mich., assignors to General Motors Research Corp., Detroit, Mich. No. 1,761,948. Jan. 10, 1927.

Method of making finned tubing. H. W. Bundy, Detroit, Mich., assignor by mesne assignments to Bundy Tubing Co., Detroit, Mich. No. 1,761,980. July 5, 1927; renewed Apr. 21, 1930.

Conveyer system for heat treating furnaces. F. W. Manker, Toledo, Ohio, assignor to Surface Combustion Company, Inc., Toledo, Ohio. No. 1,762,067. Jan. 24, 1929.

Apparatus for jointlessly welding rails. C. Stedefeld, Heidelberg, Germany. No. 1,762,085. Feb. 28, 1928; in Germany Dec. 27, 1926.

Ingot mold. E. J. Kauffman, Girard, Ohio, assignor to Valley Mould & Iron Corporation, Hubbard, Ohio. No. 1,762,098. July 19, 1929.

Cast-iron alloy. C. Taylor, Pittsburgh Pa. and H. L. Greene, Toledo, Ohio, assignors to Molybdenum Corporation of America, Pittsburgh, Pa. No. 1,762,109. April 21, 1927.

Molding apparatus for ingot molds. J. E. Perry and J. E. Lanigan, Youngstown, Ohio, assignors to Valley Mould and Iron Corporation, Hubbard, Ohio. No. 1,762,125. Apr. 6, 1928.

Welding rod. W. F. Stoody, S. M. Stoody and N. W. Cole, Whittier, Calif., assignors to Stoody Co., Whittier Calif. No. 1,757,601. Jan. 30, 1928.

Method and means of electroplating. A. O. Langseth Mansfield, Ohio, assignor to the Ohio Brass Co., Mansfield, Ohio. No. 1,757,671. Mar. 31, 1927.

Composition for soldering aluminum ware. F. L. Benedetti, Black Diamond, Wash. No. 1,758,348. May 16, 1928.

Furnace for casting iron and other difficult fusible metals under pressure. E. Petersson, Orebro, Sweden. No. 1,758,463. Nov. 5, 1926; in Sweden Jan. 9, 1925.

Method for handling sinter. A. J. Boynton, Chicago, Ill., assignor to H. A. Brassert, Inc., Chicago, Ill. No. 1,758,496. Mar. 16, 1925.

Process of and furnace for extracting metals from ores. S. C. G. Ekelund, Karskrona, Sweden. No. 1,758,786. Oct. 15, 1926; in Sweden Oct. 19, 1925.

Ingot mold. M. Blagé, Vireux-Molhain, France. No. 1,758,823. Jan. 12, 1929; in France Jan. 20, 1928.

Apparatus for freeing and extracting castings from molds. L. A. Camerota, Burlington, N. J., assignor to W. Wood, Philadelphia, Pa. No. 1,758,883. June 7, 1928.

Apparatus for making cores. G. W. Gilderman, Mishawaka, Ind., assignor to Dodge Manufacturing Co., Mishawaka, Ind. No. 1,758,888. June 4, 1927.

Method and means for the aluminothermic welding of rails and the like. E. F. Begtrup, Jersey City, N. J., assignor to Metal and Thermit Corp. Carteret, N. J. Reissue No. 17,671. (Original No. 1,741,399, filed Apr. 3, 1929.) Mar. 24, 1930.

Arc welding. R. Sarazin, Neuilly-sur-Seine, France. No. 1,759,373. Dec. 7, 1927; in France May 13, 1926.

Electrically-welded pipe and method of manufacturing the same. B. T. Andren, Milwaukee, Wis., assignor to A. O. Smith Corp., Milwaukee, Wis. No. 1,759,427. Feb. 20, 1929.

Method of heat treatment. R. E. Bissell, Cleveland Heights, Ohio, assignor to Thompson Products Inc., Cleveland, Ohio. No. 1,759,603. Aug. 2, 1926.

Metal-hardening process. G. A. Fleckenstein, Stratford; E. M. Hanf, Bridgeport; and M. L. Waterman, Fairfield, Conn., assignors to The Singer Manufacturing Co., Elizabeth, N. J. No. 1,759,690. Nov. 23, 1928.

Molding machine. R. Bachon, Bourges, France, assignor of one-half to Société Anonyme des Usines de Risieres, Bourges, France. No. 1,759,728. Dec. 31, 1927; in France Jan. 6, 1927.

Blowpipe. C. Vuillaume, Lyon, France. No. 1,759,769. May 20, 1925; in France May 20, 1924.

Roll-over traversing mechanism for molding machines. W. Lewis, Haverford, Pa., assignor to The Tabor Manufacturing Co., Philadelphia, Pa. No. 1,759,825. May 26, 1927.

Forging machine. G. F. Mills, Michigan City, Ind., assignor to Sullivan Machinery Co. No. 1,760,311. Oct. 5, 1925.

Electrode holder. H. Brock, Köln, Germany, assignor to Det Norske A/S for Elektrokemisk Industri of Norway, Oslo, Norway. No. 1,760,395. Dec. 7, 1926; in Germany Dec. 7, 1925.

Soldering iron. R. Palmer, Niskayuna, N. Y., assignor to General Electric Co. No. 1,760,519. Dec. 29, 1926.

Electric discharge device. (*Using cerium group metal.*) H. C. Rentschler, East Orange, N. J., assignor to Westinghouse Lamp Co., No. 1,760,524. Oct. 2, 1925.

Electrode (Cr alloy). H. C. Rentschler, East Orange, N. J., assignor to Westinghouse Lamp Co. No. 1,760,526. Feb. 16, 1929.

Method of arc welding. G. A. Whiting, Windsor; and R. A. Holland, West Brunswick, assignors to E.M.F. Electric Co., Proprietary Ltd., South Melbourne, all of Victoria, Australia. No. 1,760,534. June 23, 1297; in Australia July 9, 1926.

Roasting-furnace construction. H. J. Hartley, New York, N. Y., assignor to Nichols Copper Co., New York, N. Y. No. 1,760,694. Nov. 10, 1928.

Cooling bed. G. L. Fisk, Midland, Pa., assignor to Mesta Machine Co., West Homestead, Pa. No. 1,761,470. Sept. 8, 1926.

Casting readily-oxidizable metals. W. W. Smith, Buffalo, N. Y. No. 1,761,498. Apr. 18, 1928.

Core box. G. W. Elsey, Dayton, Ohio, assignor to Delco Products Corp. Dayton, Ohio. No. 1,761,522. May 25, 1929.

Method of jointlessly welding rails. C. Stedefeld, Heidelberg, Germany. No. 1,762,086. Feb. 27, 1930 (Division of original filed Feb. 8, 1928); in Germany Dec. 27, 1926.

British Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Soldering or like methods of joining metal parts. G. W. Christoph. No. 327,742. Oct. 11, 1928.

Processes and apparatus for reducing ores. J. Herrmann, B. G. Franzen, L. M. Hubbard and E. R. Zacharias. No. 327,687. Jan. 4, 1929.

Preparing aluminum and aluminum alloys. A. Pacz. No. 303, 755. Jan. 7, 1928.

Sheets of coated metal for earthed panels and other purposes. D. N. Davies, and Bakelite, Ltd. No. 327,728. Jan. 8, 1929.

Heat-treatment of steel. H. Hanemann. No. 304,196. Jan. 16, 1928.

Process and apparatus for the utilization of the heat of slag. Cie des Forges de Chatillon-Commentry et Neuves-Maisons. No. 327,732. Dec. 6, 1928.

Welded-on flange joints. Stewarts & Lloyds, Ltd., and I. Downing. No. 327,785. Jan. 28, 1929.

Welding machines. Budd Wheel Co. No. 305,097. Jan. 30, 1928.

Protection of iron surfaces against corrosion. I. G. Farbenindustrie Akt.-Ges. No. 305,218. Feb. 2, 1928.

Production of gold and silver. V. Volpato. No. 306,048. Feb. 14, 1928.

Apparatus for straightening sheet-metal members or articles. W. Burrows and B. W. Hewitt. No. 327,824. Feb. 28, 1929.

Pyrometers adapted to the control of temperature. J. Bridges and Electroflo Meters Co., Ltd. No. 327,861. Apr. 12, 1929.

Manufacture of nickel-iron alloys. General Electric Co., Ltd., S. V. Williams and G. Polgreen. No. 327,865. Apr. 18, 1929.

Method of producing shaped bodies for tools of material difficult to work such as carbides, their alloys and the like. F. Krupp Akt.-Ges. No. 313,619. June 15, 1928.

Process for electroplating metals with chromium. J. Bauer. No. 327,911. June 17, 1929.

Drawing-out hollow metallic bodies. G. Müller, and Rheinische Metallwaren- und Maschinen-Fabrik. No. 327,928. July 24, 1929.

Metallurgical furnaces. Trent Process Corp. No. 316,986. (Divided on No. 306,949.) May 11, 1928.

Manufacture and production of shaped metal articles. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.) No. 327,955. Dec. 14, 1928.

Manufacture and production of metallic carbonyls. J. Y. Johnson, (I. G. Farbenindustrie Akt.-Ges.) No. 327,956. Dec. 14, 1928.

Recovery of tin from scrap tin-plate and like tin-bearing materials. H. Wade. (W. B. Ballantine, and M. G. Gilbert.) No. 327,997. Jan. 15, 1929.

Foundry molding machines. L. H. Hines. No. 328,012. Jan 16, 1929

Electrolytic processes. K. Breusing and U. Gottesmann. No. 328,057 Jan. 30, 1929.

Method of and apparatus for salvaging storage battery plates. C. B. White. No. 328,123. Apr. 30, 1929.

Method of producing malleable metal pipes. E. Weir. No. 312,166. May 21, 1928.

Production of malleable metal pipes from hollow blanks. E. Weir. No. 316,212. July 25, 1928.

Production of malleable metal pipes. E. Weir. No. 316,571. July 31, 1928.

Aluminum alloy. H. C. Hall and T. F. Bradbury. No. 328,138. May 21, 1929.

Treatment of metals with acid liquids. Soc. of Chemical Industry in Basle. No. 313,135. June 7, 1928.

Smelting of oolitic granules and similar finely divided ores or slimes obtained from minette. P. Gredt. No. 328,240. Oct. 15, 1928.

Method and means for electrically heating metals. F. W. Thompson. No. 328,270. Oct. 18, 1928.

Articles of high resistance to wear, well polishable and neutral to chemical agents. F. Hauptmeyer. No. 307,011. Mar. 1, 1928.

Charging devices for cupolas and like furnaces. J. Robinson. No. 328,258. Jan. 22, 1929.

Truck, holder, or conveying device for use in kilns, particularly kilns of the continuous type. H. M. Robertson. No. 328,264. Jan. 23, 1929.

Tunnel kilns. H. M. Robertson. No. 328,265. Jan. 23, 1929.

Expanded metal sheet. H. Salmon and Expanded Metal Co., Ltd. No. 328,341. Feb. 1, 1929.

Induction furnaces. P. E. Bunet and Aciéries de Gennevilliers. No. 306,144. Feb. 17, 1928.

Hollow metal articles and method of making the same. T. E. Murray. No. 328,375. Mar. 4, 1929.

Treatment of iron prior to coating with tin or lead. G. Radtke (trading as Matuschek Metallindustrie G. Radtke). No. 308,804. Mar. 29, 1928.

Coating aluminum, magnesium, and their alloys with oxides of manganese. Sprenger Patentverwertung Jirotka, and B. Jirotka. No. 328,485. (Addition to No. 314,769). June 4, 1929.

Alloys. International Nickel Co., and P. D. Merica. No. 328,362. May 16, 1929.

Method of increasing heat-exchange between gases and solids or molten materials. C. Still. No. 328,640. Dec. 27, 1928.

Carbonization of nickel and nickel alloys. Westinghouse Electric & Manufacturing Co. No. 304,741. Feb. 4, 1928.

Electrodeposition of a coating of zinc. Q. Marino. No. 305,035. Jan. 28, 1928.

Cleansing or scouring iron and steel by electrochemical means. Q. Marino. No. 305,036. Jan. 28, 1928.

Treatment of platinum ores, concentrates or the like containing chromite. A. R. Powell, E. C. Deering and J. Matthey & Co., Ltd. No. 328,564. Jan. 28, 1929.

Cadmium plating. C. H. Humphries. No. 328,574. Jan. 29, 1929.

Metal-casting machines. Fry's Metal Foundries, Ltd., and J. B. Farlie No. 328,576. Jan. 29, 1929.

Proofing of iron and steel against rust. W. H. Cole. No. 328,580. (Addition to Nos. 289,906 and 305,386.) Jan. 29, 1929.

Process for utilizing gases, particularly for welding and cutting purposes. Ges. für Industriegasverwertung. No. 306,130. Feb. 16, 1928.

Recovery of nickel and other metals from ores containing nickel. F. L. Duffield. No. 328,696. Feb. 8, 1929.

Apparatus for galvanizing the insides of pipes and similarly hollow bodies. M. Schlotter. No. 328,709. Oct. 30, 1928.

Presses for drawing sheet metal and the like. H. D. Fitzpatrick (Marquette Tools & Manufacturing Co). No. 328,771. Apr. 17, 1929.

Process and apparatus for filling molds with sand or the like. W. Kurze. No. 312,369. May 26, 1928.

Centrifugal casting of hollow metal bodies. A. Possenti and C. Scorza. No. 328,882. July 30, 1929.

Safety devices for pipe supplying gas to autogenous welding and like burners. Sulzer Frères Soc. An. No. 318,624. Sept. 8, 1928.

Lead-cable covering presses. F. Krupp Grusonwerk Akt.-Ges. No. 328,896. Aug. 6, 1929.

Feeding the casting-pot of type-composing or like machines. P. A. Klinge and O. E. Borgstrom. No. 238,897. Sept. 16, 1929.

Manufacture and production of foils and the like. J. Y. Johnson. (I. G. Farbenindustrie Akt.-Ges.) No. 239,000. Jan. 5, 1929.

Soldering irons and the like. F. R. Birnie. No. 328,986. Oct. 21, 1929.

Protection of iron, copper, and their alloys. G. Nobilleau and J. Guipet. No. 308,778. Mar. 28, 1928.

Manufacture of alloys. Deutsche Edelstahlwerke Akt.-Ges. No. 311,267. May 8, 1928.

Alloy. Siemens & Halske Akt.-Ges., and W. Kroll. No. 306, 035. Feb. 14, 1928.

Welding lead. W. Smith and Expanded Metal Co., Ltd. No. 329,023. (Addition to No. 285,995.) Feb. 11, 1929.

Machine for hardening the tooth flanks of spur wheels. F. Klopp. No. 329,-054. Feb. 25, 1929.

Processes and apparatus for dephosphorizing iron. P. Ries and F. Bicheroux. No. 310,468. Apr. 26, 1928.

Method and means for degreasing articles. Carrier Engineering Co., Ltd., and K. J. R. Robertson. No. 329,156. May 10, 1929.

Siemens-Martin furnaces. H. W. de (Terni Soc. per l'Industria e l'Elettricita). No. 329,176. May 24, 1929.

Electric welding machines. F. P. McBerty. No. 329,180. May 27, 1929.

Pickling of iron and steel. Verein für Chemische und Metallurgische Produktion. No. 312,996. June 4, 1928.

Method of electrolytically producing insulating layers on aluminum and its alloys. E. W. Kuttner. No. 329,190. June 6, 1929.

Conveying devices, particularly for rolling mills. J. Euteneuer, A. Abrams, and F. Hoffmann. No. 313,930. June 19, 1929.

Method of treating lyes containing copper and zinc. N. E. Lenander and I. Ryen. No. 329,225. July 13, 1929.

Means for corrugating thin sheet metal. H. H. Berry and W. J. Markham. No. 329,234. Aug. 7, 1929.

Canadian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process of protectively treating metal. The Arthur Arent Laboratories, Inc., Des Moines, Iowa assignee of A. Arent, Evanston, Ill. No. 299,633. May 27, 1929.

Method and apparatus for shipping metal. R. T. Romine, Mount Clemens, Mich. No. 299,683. Dec. 13, 1928.

Arc welding electrode. The Alloy Welding Process Ltd., assignee of E. H. Jones, both of Islington, England. No. 299,706. Dec. 6, 1928.

Ring rolling machine. The Budd Wheel Co., Philadelphia, Pa., assignee of C. L. Wiles, Detroit, Mich. No. 299,717. Mar. 8, 1928.

Method of removing carbon impurities from tantalum. The Fansteel Products Co., Inc., North Chicago, Ill., assignee of C. W. Balke, Highland Park Ill. No. 299,739. Aug. 19, 1927.

Cutting torch. A. F. Jenkins, Baltimore, Md. No. 299,857. May 2, 1929.

Oxy-acetylene torch. A. F. Jenkins, Baltimore, Md. No. 299,858. Aug. 7, 1929.

Metal bending machine. The Tanner Manufacturing Co., Cleveland, Ohio., assignee of S. H. Gibson, Lakewood, Ohio. No. 299,940. Aug. 11, 1928.

Electrodeposition of metals. The Imperial Chemical Industries Ltd., London, assignee of J. Hollins, Middlewish, Cheshire, England. No. 299,-970. Jan. 11, 1929.

Cyanide precipitation process. The Merrill Co., San Francisco, assignee of D. Mills and T. B. Crowe, both of Palo Alto, Calif. No. 299,975. Oct. 4, 1928.

Alloy. (Fe-Be-Ni, etc.) Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, assignee of G. Masing, Berlin, Germany. No. 299,984. Feb. 1, 1929.

Converting furnace. T. Kekich, Jr., Chicago, Ill., asssignee of T. M. Kekich Alton, Ill. No. 300,007. Apr. 16, 1928.

Checker work for furnaces. F. H. Loftus, Aliquippa, Pa., and J. N. Kurtz, Pittsburgh, Pa. No. 300,020. June 24, 1929.

Lead bullion refining method. G. K. Williams, Port Pirie, South Australia. No. 300,095. Mar. 28, 1929.

Lead refining method. G. K. Williams, Port Pirie, South Australia. No. 300,096. Mar. 28, 1929.

Tuyère for slag-blowing furnaces. The Anaconda Copper Mining Co., assignee of A. Laist, both of Helena, Mont. No. 300,106. July 8, 1929.

Welding apparatus. The Bendix Brake Co., assignee of S. Whitworth and J. E. Long, all of South Bend, Ind. No. 300,117. Aug. 8, 1928.

Process of treating magnesium alloys. I. G.Farbenindustrie Akt.-Ges., Frankfurt a.M., assignee of A. Beck, Bitterfeld and H. Dibelka, Düsseldorf-Oberkassel, Germany. No. 300,015. July 23, 1929.

Manufacture of metal alloys. (Of ductile nickel-chromium steel.) Thos. Firth & Sons, Ltd., assignee of W. H. Hatfield, both of Sheffield, Yorkshire, England. No. 300,156. Dec. 21, 1928.

Method of operating tunnel kilns. The Harper Electric Furnace Corp., Philadelphia, Pa., assignee of F. A. J. Fitzgerald, Niagara Falls, N. Y., and J. Kelleher, Chippewa, Ont. No. 300,165. Mar. 5, 1928.

Process of precipitating rhodium, iridium, osmium, ruthenium, etc. N. V. Philips' Gloeilampenfabriken, assignee of E. H. Reerink, both of Eindhoven, Netherlands. No. 300,198. May 9, 1928.

Metallurgical furnace. (For production of Ti-N compounds.) The Titania Corp., Los Angeles, Calif., assignee of F. A. J. Fitzgerald, Niagara Falls, N. Y., and J. Kelleher, Chippewa, Ont. No. 300,216. Aug. 26, 1929.

Danish Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for making bearings.. The Cleveland Graphite Bronze Co., Cleveland, Ohio. No. 41,827. Aug. 6, 1928.

Process for hardening copper. N. O. Hedman, Älvsbyn, Sweden, and J. D. Larsson and N. R. Näslund, both of Korsträsk, Älvsbyn, Sweden. No. 42,011. June 15, 1929.

French Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Support for the charge of Circular Dwight-Lloyd machines. Berzelius Metallhütten G.m.b.H. No. 684,680. Nov. 9, 1929.

Method for the introduction into blast furnaces of throat gases and other gases resulting from their operation. F. W. Drucker. No. 684,779. Nov. 12, 1929.

Process and apparatus for melting easily-fusible alloys. C. Brackelsberg. No. 684,807. Nov. 13, 1929.

Device for hardening the surfaces of the journals of motor shafts or other shafts. F. Klopp. No. 684,877. Nov. 14, 1929.

Process for the simultaneous preparation of calcium titanate and ferrophosphorus. E. Urbain. No. 684,889. Feb. 13, 1929.

Cobalt steel for high-speed tools. Oesterreichische Schmidstahlwerke Akt.-Ges. No. 684,963. Nov. 14, 1929.

Process for the manufacture of basic products used in lining metallurgical furnaces. P. Ries and F. Bicheroux. No. 685,049. Nov. 16, 1929.

Process and apparatus for bottom casting cast iron under pressure. F. Stuhl. No. 685,114. Nov. 18, 1929.

Alloy steel. Fried Krupp Akt.-Ges. No. 685,130. Nov. 18, 1929.

Boxes which are particularly suitable for use in nitrization. Société Aubert & Duval Frères. No. 685,157. Nov. 19, 1929.

Process for refining nickel, copper and cupro-nickel alloys. H. J. M. E. Clerc. Addition Patent No. 36,617 (First addition to Patent No. 669,109 filed June 1, 1928.) Mar. 30, 1929.

Corrugated pipe for withstanding external pressure and process for making the same. G. A. Ferrand. No. 684,910. Feb. 14, 1929.

Product for soldering aluminum and its alloys. J. A. Rognon. No. 684,939. Feb. 18, 1929.

Process for joining aluminum and aluminum alloys with other metals by soldering. Vereinigte Silberhammerwerke Hetzel & Co. No. 685,028. Nov. 15, 1929.

Process for improving the corrosion resistance of magnesium alloy castings. I. G. Farbenindustrie Akt.-Ges. Addition Patent No. 36,601. (First addition to Patent No. 668,868, filed Feb. 1, 1929.) Mar. 15, 1929.

Drive for roller conveyors, particularly those of rolling mills. P. Muller. No. 685,284. Nov. 20, 1929.

Device for screening coke and loading it into the charging skips of blast furnaces. Gutehoffnungshütte Oberhausen A. G. No. 685,377. Nov. 22, 1929.

Process and apparatus for hardening alloys of cast iron and steel. Aubert et Duval Frères. No. 685,432. Nov. 23, 1929.

Special steel for nitriding. Central Alloy Steel Corporation. No. 685,472 Nov. 25, 1929.

Process for nitriding steel objects. Central Alloy Steel Corporation. Nos. 685,473, 685,475 and 685,476. Nov. 25, 1929.

Process and apparatus for nitriding steel objects. Central Alloy Steel Corporation. No. 685,474. Nov. 25, 1929.

Process for heat treating nitrided objects. Central Alloy Steel Corporation No. 685,477. Nov. 25, 1929.

Process and apparatus for condensing zinc vapor. The New Jersey Zinc Co. No. 685,520. Nov. 25, 1929.

Improvements to processes for making sponge metal. E. G. T. Gustafsson No. 685,546. Nov. 26, 1929.

Process and device for decreasing the dust losses in shaft furnaces. G. Eichenberg and N. Wark. No. 685,573. Oct. 3, 1929.

Process for making alloys of tungsten carbide with metals of the iron and chromium groups. R. Walter. No. 685,640. Nov. 27, 1929.

Delivery roller for rolling mills. Siemens-Schuckertwerke Akt.-Ges. No. 685,697. Nov. 27, 1929.

Improvements to processes for chill casting hollow objects. B. Fassl. No. 685,269. Nov. 20, 1929.

Process for rolling rails. C. Rötzel. No. 685,350. Nov. 21, 1929.

Process for melting and autogenous welding. F. M. Warden. No. 685,365. Nov. 22, 1929.

Improvements to acid pickling solutions. E. I. Du Pont de Nemours & Co. No. 685,525. Nov. 25, 1929.

Installation for reconditioning foundry sand. Florence Pipe Foundry and Machine Co. No. 685,613. Nov. 26, 1929.

Machine for separating thin sheets. Forges de Strasbourg (société Anonyme). No. 685,664. Nov. 27, 1929.

Process for protecting the facings of electrolytic tanks against moisture. A. C. Jessup. No. 685,408. Nov. 22, 1929.

Device for suspending objects to be treated in electrolytic baths. P. Bourgeois. No. 685,608. Nov. 26, 1929.

Process for electrolyzing sulphates dissolved in water. T. Palacio. No. 685, 624. Nov. 27, 1929.

Product for treating steels and methods of using this product. Société Maurice Poyet & Cie. No. 686,023. Mar. 4, 1929.

Process and apparatus for the reduction to small thickness by hot rolling, of metal strips and sheets. E. Broemel. No. 686,123. Dec. 4, 1929.

Process and apparatus for heat treating materials in rotary furnaces. B. M. S. Kalling and C. von Delwig. No. 686,262. Dec. 7, 1929.

Device for rotary furnaces for reducing iron ore without melting. B. M. S. Kalling and C. von Delwig. No. 686,263. Dec. 7, 1929.

Process for rendering wear-resisting, a system of mutually rubbing bodies. H. J. Van Royen. No. 686,286. Dec. 7, 1929.

Process for purifying magnesium or its alloys. The Dow Chemical Co. No. 686,335. Dec. 9, 1929.

Material having high resistance to wear and to shocks or percussion. H. J. Van Royen. No. 686,346. Dec. 9, 1929.

Product for annealing steel. H. Hanemann. Addition Patent No. 36,667. (First addition to Patent No. 667,217.) Apr. 8, 1929.

Device for electric arc welding. Société La Soudure Autogene Française. No. 685,755. Apr. 6, 1928.

Improvements to electric spot welding machines. J. E. J. Languepin. No. 685,791. Mar. 1, 1929.

Process and device for melting scrap metal. Hirsch Kupfer und Messingwerke Akt.-Ges. No. 685,872. Nov. 30, 1929.

New device for cutting with the blowpipe. M. Clause. No. 686,031. Mar. 5. 1929.

Process for making welded tubing. Air Reduction Co., Inc. No. 686,190. Dec. 6, 1929.

Process for making tanks of rustless steel. Sfinx Spojene Smaltovny a Tovarny na Kovove Zbozi Akc. Spol. No. 686,228. Dec. 6, 1929.

Process for making scale-free welded tubing. Air Reduction Co., Inc. No. 686,257. Dec. 7, 1929.

System for casting under increasing pressure. P. Mahieu. No. 686,272. Dec. 7, 1929.

Improvements to processes and to apparatus for galvanoplastic deposition on objects such as metal wire. World Bestos Corporation. No. 686,071. Nov. 26, 1929.

Process for the electrolytic deposition of zinc. U. C. Tainton. No. 686,336. Dec. 9, 1929.

Aluminum-base alloy. O. Kamps. No. 686,475. Dec. 12, 1929.

Process and apparatus for removing and carrying off throat dust from crude-gas piping and dust separators of blast furnaces and similar shaft furnaces. Vereinigte Stahlwerke Akt.-Ges. and H. Rosener. No. 686,477. Dec. 12, 1929.

Process for treating ores, metals, slags and all kinds of metallic residues in furnaces of a type and system most appropriate to the type of ore to be treated E. Somoza. No. 686,519. Nov. 21, 1929.

Improvements in the cementation of metals. American Cyanamid Co. No. 686,628. Dec. 13, 1929.

Process for refining copper. Société Etablissements Métallurgiques de Ris Orongis. No. 686,641. Dec. 14, 1929.

Process for making iron powder. Hartstoff Metall Akt.-Ges. (Hametag.) No. 686,689. Dec. 16, 1929.

Process for cleaning gases electrically, particularly throat gases. Siemens-Schuckertwerke Akt.-Ges. No. 686,759. Dec. 17, 1929.

Alloy steel objects, such as tanks, pipes, boiler parts and the like which must have high and invariable strength. Fried. Krupp Akt.-Ges. No. 686,-766. Dec. 17, 1929.

Improvements to processes for obtaining metals from their ores. C. Goetz. No. 686,782. Dec. 17, 1929.

Refining agent for type metal alloys and process for making the same. E. Hofmann. No. 686,810. Dec. 18, 1929.

Braking device for the product to be rolled, at the entrance side of rolling mills. Fried. Krupp Grusonwerke Akt.-Ges. No. 686,819. Dec. 18, 1929.

Improved air distributor for jold molding machines for making sand molds. Société Anonyme Anciens Etablissements Glaenzer & Perreaud, and G. P. Rebourg. No. 686,382. Dec. 10, 1929.

Process and device for increasing the percentage by weight of half-finished and finished rolled or forged products, with preliminary treatment of the original product with the use of a pattern. H. A. Waldrich G.m.b.H. No. 686,-534. Dec. 7, 1929.

Improvements to molding machines. The Osborn Manufacturing Co. No. 686,599. Dec. 13, 1929.

Machine for degreasing metallic or other objects. General Motors Corp. No. 686,616. Dec. 13, 1929.

Heating furnaces. Rust Furnace Co. No. 686,624. Dec. 13, 1929.

Improvements to machines for coiling metals. Scovill Manufacturing Co. No. 686,629. Dec. 12, 1929.

Process for making sand castings of magnesium and its alloys. I. G. Farbenindustrie Akt.-Ges. No. 686,642. Dec. 14, 1929.

Process for centrifugally casting thin annular objects and machine for working this process. W. Bremicker. No. 686,656. Dec. 14, 1929.

Process and machine for stripping and extracting castings from their molds. Florence Pipe Foundry and Machine Co. No. 686,660. Dec. 14, 1929.

Process and machine for making tubing with smooth fins. H. Dondorf. No. 686,690. Dec. 16, 1929.

Casting ladle. J. Wilberz. No. 686,710. Dec. 16, 1929.

Regenerative melting furnace. H. Moll. No. 686,436. Dec. 11, 1929.

Process for making mixtures of metallic and non-metallic materials. Braunschweiger Hüttenwerk G.m.b.H. No. 686,493. Dec. 12, 1929.

Process for improving alloys of magnesium and aluminum. Compagnie de Produits Chimiques et Electrométallurgiques Alais, Froges & Camargue. No. 686,855. Mar. 8, 1929.

Improvements to processes for obtaining aluminum from bauxites or from non-halogenated ores of alumina. J. C. Seailles. No. 686,894. Mar. 13, 1929.

Improvements in the casting of cast iron. F. Stuhl. No. 686,909. Mar. 15, 1929.

Improvements in the production of aluminum by electrolysis. Compagnie de Produits Chimiques et Metallurgiques Alais, Froges & Camargue. No. 686,914. Mar. 15, 1929.

Process for rolling narrow strips of sheet metal. C. Rötzel. Addition Patent No. 36,753. (First addition to Patent No. 659,703.) Mar. 25, 1929.

Improvements to electric welders. L. Bourdelles. No. 686,882. Mar. 12, 1929.

Stamping press. J. Grunberg. No. 686,942. Dec. 19, 1929.

Improvement in the construction of electric welding machines. Electro-Soudure, Soc. An. No. 687,020. Dec. 14, 1929.

Process and machine for making wire cables in which the wires are under a low elastic tension. Akt.-Ges. für Seil-Industrie vorm. Ferd. Wolff. No. 687,028. Dec. 20, 1929.

Process and apparatus for making flexible metallic tubing. Société Anonyme des Tuyaux Flexibles Levasseur. No. 687,064. Dec. 20, 1929.

Process and apparatus for making corrugated tubing. Société Anonyme des Tuyaux Flexibles Levasseur. No. 687,100. Dec. 21, 1929.

Flexible tubing. Société Anonyme des Tuyaux Flexibles Levasseur. No. 687,175. Dec. 23, 1929.

Process for electric welding and cutting, with magnetic stabilization. R. Sarazin. No. 687,215. Dec. 24, 1929.

Cast light metal spool and process for making it. G. Decombe. No. 687,228. Dec. 26, 1929.

Device for connecting condensers in induction furnace circuits. Société Générale d'Applications Electro-Thermique. No. 686,870. Mar, 9, 1929.

German Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Electric salt-bath crucible furnace with cooling device. Siemens-Schuckertwerke Akt.-Ges., Berlin-Siemensstadt, Germany. No. 497,912. (Addition to Patent No. 491,600.) Feb. 5, 1929; in the United States Mar. 15, 1928.

Sand slinging machine. M. V. N. Leroy, Angouleme-Sillac, Charante, France. No. 497,740. Nov. 23, 1928.

Process for extracting titanium ore. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 497,931. Dec. 18, 1926.

Improvable and unimprobable silver alloys containing antimony. W. Guertler, Berlin-Charlottenburg. Germany. No. 497,932. Oct. 26, 1927.

Alloys of aluminum with metals of the iron group. Karl Schmidt, G. m. b. H., Neckersulm, Germany. No. 497,933. June 8, 1924.

Treatment of aluminum alloy castings containing silica for the purpose of improving their physical properties. Metallgesellschaft Akt.-Ges., Frankfurt a. M., Germany. No. 497,896. Dec. 30, 1921; in the United States Jan. 4, 1921.

Muffle annealing furnace. Vereinigte Leichtmetallwerke G. m. b. H., Bonn a. Rh., Germany. No. 497,751. Nov. 3, 1928.

Apparatus for electroplating the interior of long hollow bodies. W. A. F. Pfanhauser, Leipzig, Germany. No. 497,941. Mar. 15, 1929.

Process for pickling objects of iron or its alloys. Werk Rothau der Eisenwerk Akt-Ges. Rothau-Neudek; and F. Eisenkolb, Rothau, Germany. No. 497,942. Feb. 28, 1926.

Apparatus for producing an insulating coating on wire or the like made of aluminum or aluminum alloys. Spezialfabrik für Aluminium-Spulen und Leitungen G. m. b. H., Berlin, Germany. No. 497,943. (Addition to Patent No. 459,722.) Oct. 23, 1927.

Forging machine. Eumoco Akt-Ges. für Maschinenbau, Schlebusch-Manfort b. Köln, and A. Schneider, Düsseldorf, Germany. No. 497,-796. July 19, 1927.

Machine for bending tubing of low-strength metals such as aluminum and the like. A. Hageböke, Bremen, Germany. No. 497,850. Nov. 4, 1927.

Device for conveying material, particularly for rolling mill installations. Fried. Krupp Grusonwerk Akt.-Ges., Magdeburg,-Buckau, Germany. No. 498,356. Mar. 19, 1929.

Machine for the continuous rolling of strip metal. H. Eitel, Herbede, Westfalen, Germany. No. 498,204. Feb. 11, 1927.

Device for intermittently raising rolled material. Demag Akt.-Ges., Duisburg, Germany. No. 498,205. Oct. 7, 1928.

Process for making metal wire. K. Suresch, Saarbrücken, Germany. No. 498,046. Feb. 1, 1928.

Multiple wire-drawing machine. W. Gerhardi, Maschinenbau-anstalt und Eisengiesserei, Lüdenscheid, Germany. No. 498, 047. Feb. 19, 1928.

Machine for forming the felloe on a wheel built up of two disks. The Dunlop Rubber Co., Ltd., Birmingham, England. No. 498,429, July 8, 1925; in Great Britain June 2, 1925.

Means for sealing electric bright-annealing furnaces. Siemens-Schuckertwerke Akt.-Ges., Berlin-Siemensstadt, Germany. No. 498,140. Dec. 4, 1925.

Electrically heated annealing furnace. Heraeus-Vacuumschmelze Akt.-Ges. and W. Rohn, Hanau a.M., Germany. No. 498,500. Dec. 16, 1924.

Process for making electrodes for electric furnaces. Siemens-Planiawerke Akt.-Ges. für Kohlefabrikate, Berlin-Lichtenberg, Germany. No. 498,443. Sept. 16, 1925.

Device for making refractory linings for electric furnaces. H. Neuhauss, Sayn a.Rh., Germany. No. 498,534. Nov. 28, 1928.

Process for welding and soldering, particularly with electrically-produced radiant heat. E. Schröder, Berlin, Germany. No. 498,501. June 29, 1927.

Process for increasing the temperature of iron flowing from a cupola to its forehearth by blowing secondary air and furnace gases on to the iron flowing into the forehearth. R. Hemprich and J. Mertens, Berlin, Germany. No. 498,447. Dec. 9, 1928.

Lifting device, particularly for lifting the cope and the mold board from the drag in molding machines. E. M. Cole, Charlotte, N. C., No. 498,302. Apr. 15, 1927.

Recovery of metals or metallic compounds which are insoluble in ammoniacal liquors. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 498,164. (Addition to Patent No. 488,047.)

Process for making a hard fused alloy for tools, particularly drawing dies. Patent-Treuhand-Gesellschaft für elektrische Glühlampen m. b. H Berlin, Germany. No. 498,349. Mar. 22, 1923.

Process for producing aluminum. Aluminium Limited, Toronto, Ont. No. 498,238. Dec. 21, 1923; in the United States, Dec. 21, 1922.

Bulk galvanizing apparatus with rotating holder for the goods to be galvanized. F. Kirschner and J. Hess, Wien, Austria. No. 498,324. May 3, 1927.

Process for removing gas inclusions from objects electroplated with metal. J. von Bosse, Böhlitz-Ehrenberg, near Leipzig, Germany. No. 498,126. Mar. 8, 1927.

Rotary shear for cutting rolled material. Demag Akt.-Ges., Duisburg, Germany. No. 498,175. (Addition to Patent No. 483,670.) Mar. 12, 1927.

Apparatus for cutting metals with the blowpipe. R. A. Ryan, London, and Hancock & Co., Ltd., Croydon, England. No. 498,177. Apr. 21, 1929; in Great Britain July 7, 1928.

Tubing mill with conical mandrel and rolls set somewhat obliquely to this conical mandrel. P. Slesazeck, Berlin-Tempelhof, Germany. No. 499,043 Feb. 21, 1929.

Machine for rolling twist drill blanks. M. Schmachtenberg, Köln-Ehrenfeld Germany. No. 498,656. Mar. 18, 1926.

Process for making metallic carbonyls. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 498,977. May 24, 1928.

Device for charging continuously-operating electric annealing furnaces with bulk wares, all of the same kind. Akt.-Ges., Brown, Boveri & Cie., Baden, Switzerland. No. 498,038. Oct. 15, 1927.

Device for cooling castings of steel or other alloys by blowing air into the annealing chamber after termination of the annealing operation. Hermann & Söhne G.m.b.H., Neubiberg, München, Germany. No. 498,813. Jan. 26, 1928.

Electric furnace. E. F. Russ, Köln, Germany. No. 498,827. Mar. 6, 1926.

Induction furnace with a heating channel sloping downward to connect with a hearth. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 498,828. Nov. 15, 1925.

Process for making electrodes. G. Polysius Akt.-Ges., Dessau and R. Märtens, Berlin, Germany. No. 498,796. Sept. 16, 1926.

Rolling mill for the quantity production of objects, fittings for example, with parallel rolls. O. Reifurth, Immigrath, Rhld., No. 497,233. Mar. 20, 1928.

Tipping device for sintering installations with movable sintering pots. H. G. Torulf, Stockholm, Sweden. No. 496,907. Jan. 24, 1928.

Process and apparatus for hardening crank-shafts having hollow journals with cemented bearing surfaces. A. Luschenowsky, Berlin, Germany. No. 496,908. Mar. 2, 1929.

Method and means for starting up coal-dust-fired hearth furnaces, in which the combustion chamber is first brought up to temperature and then the hearth heated. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 497,107. Oct. 31, 1924.

Electrode furnace. Société Electrometallurgique de Montricher, St. Julien-de-Maurienne, France. No. 496,918, Dec. 29, 1926; in France Dec. 31, 1925 and Dec. 21, 1926.

System for operating induction furnaces not having a closed iron circuit. Allmänna Svenska Elektriska Aktiebolaget, Västerås, Sweden. No. 496,-919. Apr. 14, 1929; in Sweden Apr. 21, 1928.

Attachment of the current-carrying electrode clamp to the electrode holder. Demag. Akt.-Ges., Duisburg, Germany. No. 496,920. Nov. 17, 1928.

Electrode clamp consisting of two opposite water-cooled parts. G. Hilger, Gleiwitz, Germany. No. 496,921. Apr. 25, 1926.

Clamping device for electric heating machines, particularly butt-welding machines. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 496,743. June 14, 1925.

Welding machine. International Combustion Engineering Corp., New York, N. Y. No. 496,969. Oct. 18, 1925; in the United States Apr. 8, 1925.

Slide valve for all kinds of furnaces, particularly regenerative furnaces. W. Schwier, Düsseldorf, Germany. No. 497,001. Feb. 9, 1927.

Cross-current recuperative plate-preheater, particularly for preheating air for combustion, J. Ejström, Norrköping, Sweden. No. 497,003. Oct. 24, 1924.

Pressure molding machine for metal and iron foundries. The Westinghouse Brake and Saxby Signal Co., Ltd., London, England. No. 496,852. June 2, 1928; in Great Britain July 27, 1927.

Elastic core for making pipes of genuine bronze. G. Bühler, Vienna, Austria. No. 496,819. Nov. 5, 1927.

Machine for the simultaneous casting of several hollow ingots of genuine bronze. G. Bühler, Vienna, Austria. No. 496,820. Nov. 5, 1927.

Pretreatment of copper ores or other ores before leaching. F. Dietzsch, Kingston-on-Thames, Surrey, England. No. 496,931. Oct. 28, 1927.

Process for producing pure bismuth and its compounds from its ores, concentrates and the like by a chemical method. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 498,921. Sept. 1, 1927.

Alloy of copper, tin, nickel and manganese for heavily loaded bearings or for rapidly-rotating shafts. Böntgen & Grah, Wald, Rhld., Germany. No. 498,889. Oct. 25, 1927.

Process for purifying aluminum and its alloys. Metallgesellschaft Akt.-Ges. Frankfurt a.M., Germany. No. 499,003. Feb. 9, 1926.

Production of pure aluminum-silicon alloys from crude bauxite or aluminum silicates. K. Schmidt, Neckarsulm, Germany. No. 498,616. June 8, 1924.

Machine for welding circular seams. Peco Elektrische Schweissmaschinenfabrik Rudolf Bocks, Pasing, near München, Germany. No. 498,738. June 13, 1928.

Welding burner. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 499,517. Dec. 4, 1928.

Rolling mill train for continuous rolling, particularly of strip and wire, with laterally adjustable guides. Alsdorfer Hütte G.m.b.H., Alsdorf, near Betzdorf, Sieg, Germany. No. 499,518. Feb. 24, 1929.

Electromagnetically-actuated adjusting device for the rolls of rolling mills. Fried. Krupp Grusonwerk Akt.-Ges., Magdeburg-Buckau, Germany. No. 499,519. Nov. 3, 1928.

Roller for the roller beds of rolling mills. Siemens-Schuckertwerke Akt.-Ges. Berlin-Siemensstadt, Germany. No. 499,227. Dec. 2, 1928.

Automatic machine for rolling zinc cylinders for the cups of primary cells. Fritz Thiel, Metallwarenfabrik G. m. b. H., Ruhla, Germany. No. 499,-416. Sept. 6, 1928.

Method of contracting or expanding the edges of sheet metal vessels. Mauser Maschinenbau G. m. b. H., Köln-Bickendorf, Germany. No. 499,210. Nov. 28, 1926.

Process for the production of iron carbonyl from sponge iron. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 499,296. Nov. 16, 1924.

Water-cooled hot blast valve. H. Rösener, Duisburg-Meiderich, Germany. No. 499,130. Mar. 27, 1928.

Method of constructing high-voltage electric furnaces. A/S Norsk Staal (Elektrisk-Gas-Reduktion), Oslo, Norway. No. 499,454. Aug. 7, 1928.

Coil for electric induction furnaces. Hirsch, Kupfer- und Messingwerke Akt.-Ges., Berlin, Germany. No. 499,534. Apr. 21, 1927.

Electric welding machine with several pairs of electrodes. Edward G. Budd Manufacturing Co., Philadelphia, Pa. No. 499,349. Aug. 7, 1926; in the United States Aug. 15, 1925.

Method of operating coal-dust-fired rotary drum furnaces for melting metals. C. Brackelsberg, Milspe, Germany. No. 499, 128. Mar. 10, 1927.

Device for setting green cores in the drag of foundry-molding flasks. Siemens-Schuckertwerke Akt.-Ges., Berlin-Siemensstadt, Germany. No. 499,-460. Nov. 2, 1927.

Machine for making sand molds and cores with dove-tail or similarly undercut recesses. Metallgesellschaft A. G., Frankfurt a.M., Germany. No. 499,175. Dec. 29, 1925.

Process for improving aluminum-zinc alloys. Th. Goldschmidt Akt.-Ges., Essen, Germany. No. 499,424. (Addition to Patent No. 445, 714.) Oct. 16, 1924.

Device for measuring the temperature of incandescent bodies. Kaiser Wilhelm Institut für Eisenforschung E. V., Düsseldorf, Germany. No. 499,544. Nov. 1, 1928.

Radiation pyrometer having an objective lens. A. Schwartz, Berlin-Schlactensee, Germany. No. 499,309. Sept. 2, 1925.

Device for controlling a plurality of electric drives, particularly those of electrically-driven rolling mills. Vereinigte Stahlwerke Akt.-Ges., Düsseldorf, Germany. No. 500,069. June 17, 1927.

Process for rolling thin metal foil, particularly aluminum foil. L. Rado, Berlin-Charlottenburg, Germany. No. 499,813. June 3, 1927.

Rolling mill, particularly one for rolling sheets. F. Menne, Weidenau, Sieg, Germany. No. 500,070. May 22, 1928.

Conveyor roller, particularly for the rollways of rolling mills. A. Leuchs, nee Rösicke, Berlin-Charlottenburg, Germany. No. 500,071. Feb. 12, 1928.

Metal-extrusion press. Hydraulik G. m. b. H., Duisburg, Germany. No. 499,790. Dec. 5, 1925.

Pipe-flanging machine. F. Brzoska, Düsseldorf, Germany. No. 499,814. Oct. 23, 1928.

Process for removing volatile iron compounds from gases, particularly gases containing carbon monoxide. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 499,652. June 16, 1925.

Method and tuyère for decreasing the extent of the oxidizing zone at the tuyère level of shaft furnaces. Gutehoffnungshütte Oberhausen Akt.-Ges., Oberhausen, Rheinland, Germany. No. 499,711. Oct. 10, 1926.

Process for producing gray cast iron by superheating molten cast iron before pouring. H. Hanemann, Berlin-Charlottenburg, Germany. No. 499,-712. Nov. 26, 1925.

Two-part pouring gutter for open-hearth furnaces. Rasselsteiner Eisenwerks-Gesellschaft Akt.-Ges., and H. Moll, Neuwied-Rasselstein, Germany. No. 499,831. Feb. 22, 1929.

Annealing and tempering apparatus, particularly for laminated objects, such as laminated springs. G. Schönwetter, Berlin-Wilmersdorf. No. 499,-595. Dec. 25, 1928.

Device for interchanging heating elements set in the heart of electric furnaces. Siemens & Halske Akt.-Ges., Berlin-Siemensstaht, Germany. No. 499,612. Dec. 5, 1928.

Method of operating high-frequency induction furnaces on polyphase current. M. Surganinoff, Wien, Austria. No. 499,743. Sept. 24, 1927; in Austria Oct. 30, 1926.

Electric resistance welding or heating machine with multiply subdivided secondary coil. No. 499,988. July 25, 1920.

Flask pin. Metallgesellschaft A.G., Frankfurt a.M., Germany. No. 499,-858. Oct. 27, 1926.

Method of cleaning adhering electrolyte salt-mixture from the electrodes, in the electrolytic production of aluminum. Aluminium-Industrie Akt.-Ges., Neuhausen, Switzerland. No. 500,015. Dec. 1, 1928.

Bright-annealing metals. Metallgesellschaft A.G., Frankfurt a.M., Germany. No. 499,936. Sept. 9, 1926.

Anodes for electrolytic chromium-plating baths. W. G. Poetzsch, Leipzig, Germany. No. 499,718. Mar. 22, 1928.

Apparatus for the electrolytic production of sheet and tubing. E. Kelsen, Wien, Austria. No. 499,693. Aug. 30, 1927.

Method and device for removing excess zinc from hollow portions of hot galvanized objects. F. Krieger, Hilden, Kr. Düsseldorf, Germany. No. 499,694. Oct. 18, 1927.

Process for making tinned sheets and sheet-metal objects. F. E. Krauss, Schwarzenberg, Sa., Germany. No. 499,719. July 10, 1928.

Carrier rack for sheet-pickling machines. G. Knoll, München, Germany. No. 499,695. Feb. 5, 1929.

Bending machine. W. Scharff, Frankfurt a.M., Germany. No. 499,627. Aug. 27, 1929.

Roller bearing for rotary tubular furnaces and the like. Fried. Krupp Grusonwerk Akt.-Ges., Magdeburg-Buckau, Germany. No. 499,783. July 2, 1929.

Cooler for rotary furnaces, for roasting, calcining and sintering. N. Young, Frankfurt a.M., Germany. No. 499,722. Mar. 14, 1928.

Shaft furnace. Fried. Krupp Grusonwerke Akt.-Ges., Magdeburg-Buckau, Germany. No. 499,784. Mar. 16, 1929.

Italian Patents

Subject of Invention, Patentee, Patent No. and Filing Date.

Improvements in the extraction of zinc. H. E. Coley, London, England. No. 266,257. Jan. 20, 1928; in Great Britain Feb. 2, 1927. (British Patent No. 281,129.)

Process for decomposing titaniferous ores. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 265,939. Jan. 20, 1928; in France Mar. 10, 1927. (French Patent No. 630,630.)

Aluminum alloy having high mechanical properties and chemical resistance, and process for improving the same. Th. Goldschmidt. Akt.-Ges., Essen, Germany. No. 266,018. Jan. 18, 1928; in Germany Jan. 20, 1927.

Improvements in steel manufacture. Granular Iron Co., New York, N. Y. No. 266,304. Jan. 31, 1928.

Process for producing metals and alloys. T. R. Haglund, Stockholm, Sweden. No. 266,307. Jan. 31, 1928; in Sweden Feb. 1, 1927.

Improvements in the production of carbon-free metals. International Nicke Co., New York, N. Y. No. 266,139. Dec. 12, 1927; in the United States May 19, 1927, in the name of P. D. Merica and A. E. Kayes.

Alloy steel having great resistance to high temperature. Fried. Krupp Akt.-Ges., Essen, Ruhr, Germany. No. 266,125. Jan. 20, 1928; in Germany Jan. 28, 1927.

Improvements to processes for making steel. F. C. Langenberg, New York, N. Y. and M. A. Grossmann, Canton, Ohio. No. 266,450. Jan. 30, 1928.

Process for making steel which is insensible to cold working and to ageing. H. J. Van Royen, Hörde, Westfalen, Germany. No. 266,532. Feb. 18, 1928; in Germany Feb. 21, 1927.

Process for making an aluminum-silicon alloy. Vereinigte Aluminium Werke Akt.-Ges., Lausitz, Germany. No. 265,716. Jan. 4, 1928.

Process for treating manganese ore. John C. Wiarda & Co., New York, N. Y. No. 266,000. Mar. 27, 1928.

Alloy for welding aluminum and process for making it. G. Bossi, Milano, Italy. No. 265,872. Jan. 12, 1928.

New process for welding tubing, particularly bicycle tubing. E. Bozzi, S. A., Milano, Italy. No. 265,729. Jan. 4, 1928; No. 265,871. Jan. 12, 1928.

Method and machine for welding. Edward G. Budd Manufacturing Co., Philadelphia, Pa. No. 266,274. Jan. 24 1928; in the United States Mar. 18, 1927, in the name of J. W. Meadowcroft.

Improvements to electric welding machine. Budd Wheel Co., Philadelphia, Pa. No. 266,195. Jan. 17, 1928.

Process and machine for cold rolling strips of metals and alloys. O. Busse, Burgöner, near Hettstedt, Südharz, Germany. No. 266,400. Jan. 26, 1928; in Germany Dec. 3, 1927.

Method of bending magnesium alloy sections. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 266,447. Jan. 27, 1928; in Germany Jan. 28, 1927

Process for drawing sections made of magnesium alloy sheet. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 266,448. Jan. 27, 1928; in Germany Jan. 28, 1927.

Improvements to foundry presses. C. J. Hult, Tureberg, Sweden. No. 266,-469. Feb. 4, 1929.

Mechanism for coupling rolling mill rolls. Mannesmannröhren-Werke, Düsseldorf, Germany. No. 266,326. Mar. 30, 1928; in Germany May 4, 1927.

Mold for casting cylinders or the like. G. Marengo, Torino, Italy. No. 266,-440. Mar. 28, 1928.

Process and machine for making autogenously welded tubing. O. Meyer-Keller & Cie., Lucerne, Switzerland. No. 266,510. Feb. 6, 1928; in Germany July 27, 1927.

Machine for rolling tubing from a hollow billet. M. Roeckner, Mülheim, Ruhr, Germany. No. 266,318. Jan. 25, 1928; in Germany Feb. 25, 1927.

Process for rolling tubing from hollow billets, and machine for working this process. M. Roeckner, Mülheim, Ruhr, Germany. No. 266,320. Jan. 25, 1928; in Germany Feb. 25, 1927.

Process and apparatus for coating strip iron with a corrosion-proof coating. C. Rötzel and G. Krug. Gelsenkirchen, Westfalen, Germany. No. 266,075. Jan. 21, 1928; in Germany Jan. 22, 1927; in the name of C. Rötzel.

Electric arc welding device. O. Schuchmacher, Hamburg, Germany. No. 265,736. Jan. 11, 1928.

Improvements to apparatus for producing electrolytic sheets and the like. J. Carl, F. A. Schütte, Altdorf, Uri, Switzerland. No. 265,857. Jan. 11, 1928.

Process and means for preparing foundry molds. H. B. Smith Co., Westfield, Mass. No. 266,277. Jan. 24, 1928.

Oil-base varnish for protecting metallic objects against rust. A. Stefani, Livorno, Italy. No. 265,953. Aug. 9, 1927.

Method and apparatus for making welds. Sulzer Frères Soc. An., Winterthur, Switzerland. No. 266,194. Jan. 17, 1928; in Switzerland Feb. 28, 1927; in the name of C. Schaer.

Furnace for heating blanks. Allgemeine Elektricitäts Gesellschaft, Berlin, Germany. No. 266,323. Jan. 25, 1928; in Germany Jan 29, 1927.

Induction furnace. E. F. Russ, Köln, Germany. No. 265,978. Jan. 21, 1928.

Swedish Patents

Subject of Invention, Patentee, Patent No. and Filing Date

Electric bright-annealing furnace. Siemens-Elektrowärme G.m.b.H., Sörnewitz, near Meissen, Germany. No. 69,283. Dec. 3, 1926. Priority Date Dec. 5, 1925

Electric melting furnace. Det Norske A/S for Elektrokemisk Industri, Norsk Industri-Hypotekbank, Olso, Norway. No. 69,626. Apr. 4, 1924. Priority Date May 16, 1923.

Process for making nickel alloys. Electrical Research Products, Inc., New York, N. Y. No. 69,632. Dec. 29, 1924.

Copper-silicon-iron-nickel alloy. Metallbank und Metallurgische Gesellschaft Akt.-Ges., Frankfurt a.M., Germany. No. 69,633. Mar. 5, 1928. Priority Dates Mar 5., and June 20, 1927.